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SPECIALIZED UNDERGRADUATE PILOT TRAINING: TANKER/TRANSPORT/BOMB--ETC(U)

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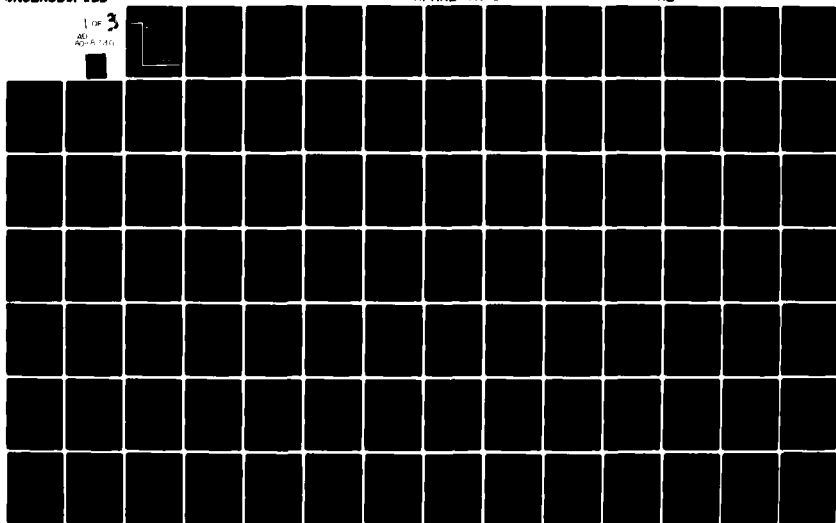
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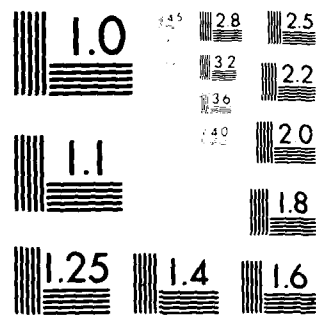
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SPECIALIZED UNDERGRADUATE PILOT TRAINING:  
TANKER/TRANSPORT/BOMBER (TIB)  
TRAINING REQUIREMENTS

By

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Aug 1980

Final Report

Approved for public release; distribution unlimited.

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This final report was submitted by Logicon, Inc., 4010 Sorrento Valley Blvd., San Diego, California 92138, under Contract F33615-78-C-0059, Project 1123, with the Operation and Training Division, Air Force Human Resources Laboratory (AFSC), Williams Air Force Base, Arizona 85224. Dr. Ronald G. Hughes was the Contract Monitor for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A one-year contract effort was performed in response to the USAF Air Training Command Request for Personnel Research No. 75-27. *Tanker/Transport/Bomber (TTB) Lead-In Training.* The effort accomplished the following: (a) identification of training requirements for the TTB phase of a proposed dual-track UPT program. These requirements cover those tasks which are common to the B-52, KC-135, C-130, C-141, C-9, and C-5 aircraft, (b) development of ways of estimating the training benefits to be derived by MAC and SAC from pilot lead-in training on these common tasks, (c) development of a method for determining the generalizability of any subset of TTB lead-in training tasks to the entire domain of TTB training tasks, and (d) development of an approach to the measurement of aircrew performance in the TTB training environment.		

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This study effort was prerequisite to the Air Training Command development of a syllabus for the TTB track of a Specialized Undergraduate Pilot Training System (SUPTS).

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SECTION 1  
REQUIREMENTS, COMMONALITIES,  
AND BENEFITS

## CHAPTER 1

### TANKER/TRANSPORT/BOMBER TOTAL TRAINING REQUIREMENTS

#### 1.1 BACKGROUND AND INTRODUCTION

The Air Force has been evaluating the feasibility of Specialized Undergraduate Pilot Training (SUPT). In this contract, Logicon has conducted a study to: (1) identify the lead-in training requirements which SUPT would entail for Tanker/Transport/Bomber (TTB) pilots, (2) develop a method for determining the generalizability of any given subset of tasks selected for TTB training to the entire domain of tasks, and (3) develop a methodology for use in the measurement of aircrew performance.

This report is one volume with two major sections, plus three appendices. Section 1 deals with the requirements, commonalities and benefits of a TTB training program. Section 2 presents a methodology for measurement of aircrew performance. Appendix A presents the questionnaire used in the study. Appendix B gives responses to selected questions and Appendix C describes a method for predicting the generalizability of training tasks.

#### 1.2 PROCEDURES AND ASSUMPTIONS

##### 1.2.1 Procedures

Task 1.1 required the compilation of the total set of current Strategic Air Command (SAC) and Military Airlift Command (MAC) pilot/copilot training requirements. In order to accomplish this task, Logicon used the following procedures: (1) relevant Air Force documents were reviewed, (2) extensive interviews were conducted with SAC and MAC training staff personnel, instructors, and students; and (3) questionnaires were administered (this work is described in further detail below), and the results were analyzed. (Results are given in Sec. 1.3.)

The total set of training requirements were sought for B-52, KC-135, C-9, C-5, C-141, and C-130 aircraft. These aircraft were selected by the major TTB commands as those in which recent UPT graduates would be trained. Logicon (1) conducted 17 different interviews with a total of 30 training staff and 27 instructor personnel, (2) obtained completed questionnaires from 97 staff, flight, academic and simulator instructors and 63 students. (Questionnaires and other data-gathering instruments are reproduced in Appendix A.) The only students who were interviewed at the Combat Crew Training Squadrons (CCTSs) were recent UPT graduates. Interviews and questionnaires were obtained at the following places.

Offutt Air Force Base - SAC HQ

Scott Air Force Base - MAC HQ & C-9

Altus Air Force Base - C-141

Little Rock Air Force Base - C-130 (All Models)

Castle Air Force Base - B-52/G/H & KC-135

Carswell Air Force Base - B-52 D & CFIC

American Airlines, Dallas Texas - Commercial Training

Williams Air Force Base - AFHRL/FT

Randolph Air Force Base - ATC HQ/UPT

Moffett Naval Air Station - Navy Advanced Flight Training

Corpus Christi Naval Air Station - Navy UPT

Air Force documentation in the form of SAC and MAC training and evaluation manuals and regulations was another major data source.

Note: At the very end of the contract period, MAC made the decision to include the C-5 to the list of aircraft which recent UPT graduates can be initially assigned. At the decision date all interviews, questionnaires and surveys had been completed and as a result, this report contains little data on the C-5. A C-5 instructor pilot was interviewed as a Subject Matter Expert (SME) and provided the data for Chapter 2.

#### 1.2.2 Assumptions

There are many varied options discussed in the published reports concerned with future undergraduate pilot training. At the printing of this study few if any decisions have been made. Therefore, Logicon had to make some rather general assumptions from the Air Force data available. The assumptions were:

1. A track selection system will enter pilot candidates into either a Fighter/Attack/Reconnaissance (FAR) or TTB track prior to any flying.
2. The specialized training option will be similar to the one shown in figure 1-1.
3. Only fixed wing pilot training programs are considered.
4. UPT will train to first pilot standards for all graduates.
5. TTB graduates will not have initial assignments to FB-111, SR-71, or KC-10 aircraft.
6. Foreign countries' needs have not been considered.
7. All students will receive the same training in primary. The study, comparison of UPT Generalized vs. Specialized, 5 March 1976, shows the approximate distribution of flying time by training aircraft. It shows the training requirements of the T-37 phase for FAR & TTB tracks to be exactly the same (see the following table).

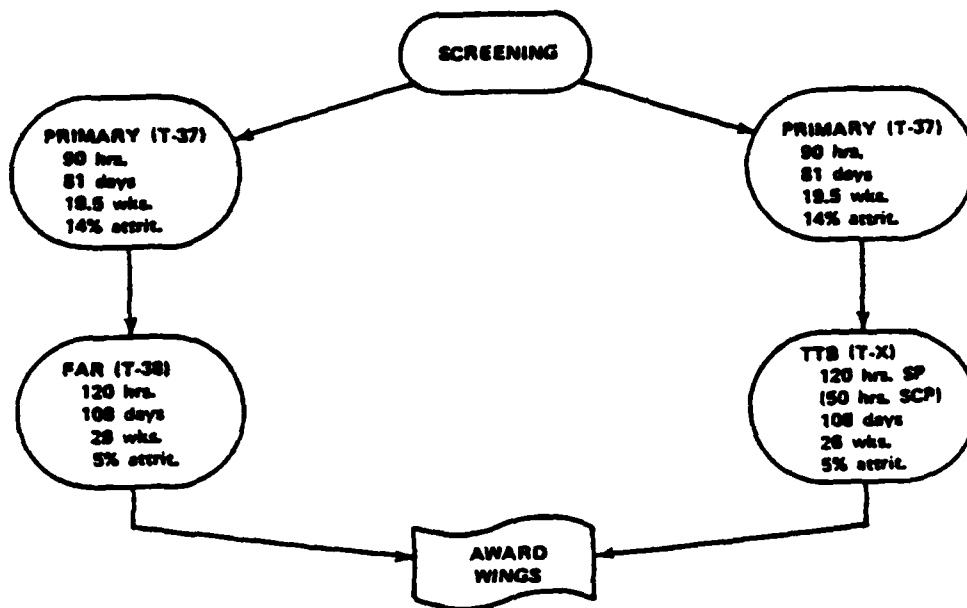


Figure 1-1. Specialized Training Option

<u>FAR TRACK HOURS</u>	<u>DUAL</u>	<u>SOLO</u>	<u>TOTAL</u>
T-37 BASIC	13.0		13.0
CONTACT	28.3	9.8	38.1
INSTRUMENTS	14.3		14.3
NAVIGATION	9.0		9.0
FORMATION	13.0	2.6	15.6
	<u>77.6</u>	<u>12.4</u>	<u>90.0</u>
<u>TTB TRACK HOURS</u>	<u>DUAL</u>	<u>SOLO</u>	<u>TOTAL</u>
T-37 BASIC	13.0		13.0
CONTACT	28.3	9.8	38.1
INSTRUMENTS	14.3		14.3
NAVIGATION	9.0		9.0
FORMATION	13.0	2.6	15.6
	<u>77.6</u>	<u>12.4</u>	<u>90.0</u>

8. The training requirements identified in this study are for basic TTB lead-in training and will be taught at the completion of the T-37 phase.

In addition, a number of working assumptions had to be made to provide a basis for the data analysis performed thus far in the contract. A major assumption involving the availability of simulators was made. (This assumption relates to part of Section 2, Chapter 2, paragraph 2.1, describing the extent to which common tasks can be trained on current simulators.) The assumption was that any existing simulator, regardless of ownership, was theoretically available to the Air Force; and that simulators now on order would, when delivered to the Air Force, actually work according to the procurement specifications. Another important assumption was that after SUPT and assignment of new pilots to units, transfers of pilots to other aircraft and commands would be minimal.

In view of the rather "macro" level of task analysis, Logicon also assumed that it was necessary to use rather general terms in the description of the associated conditions, performance and standards.

### 1.2.3 Crew Coordination

Logicon's procedures and assumptions regarding crew coordination are briefly reviewed in the following paragraphs.

An effort was made to treat crew coordination as a dimension of TTB tasks rather than as a type of task in and of itself. In addition to crew coordination, several other tasks fell into this category: for example, collision avoidance, decision making, communication and checklist usage were found to be inseparable from all the others. A pilot wants to avoid colliding with other aircraft as he/she takes off and climbs out ... and in all other phases of flight as well! Collision avoidance, therefore, is a task which overlaps the others. In describing each of the other functions (such as air drop fundamentals and visual/airborne radar navigation), Logicon could have stated explicitly that the functions of collision avoidance and crew coordination, etc., were also being performed. However, this would have caused repetitious writing. It was also noted that the major commands at the present time do not treat decision making, etc., as dimensions; instead, these tasks are still evaluated and recorded as separate areas. Therefore, Logicon has described crew coordination as a separate task area even though it is actually an aspect or a dimension of other tasks.

## 1.3 TTB TRAINING REQUIREMENTS: TWO ASSESSMENTS

### 1.3.1 SUPT Intercommand Conference Assessment

The Future Undergraduate Pilot Training Mission Analysis, AFSC-TR-72-001, conducted in CY 71, identified 30 broadly defined undergraduate pilot training requirements which were thought to be requirements of the 1975-1990 time frame.

An ATC Inter-Command UPT Conference, held in Sept. 75, reevaluated the future training requirements. Representatives of the major flying commands found that all training requirements, with three exceptions (Tactical Formation, Basic Fighter Maneuvers, and Air-to-Ground Fundamentals), are valid for UPT.

Of the remaining 27 undergraduate pilot training requirements, the present UPT program provides in-depth instruction in 22. Two others, Low-Level Navigation and Formation Landing, are introduced, but not to the standards as specified by the 1971 study. In a specialized UPT program, all 27 training requirements could be taught in-depth. These training requirements were also accepted by the SUPT Intercommand Conference held in September 1978.

The undergraduate pilot training requirements, acceptable for TTB training as defined by the Conferences, are listed below.

1. Ground Operations. Operations accomplished before takeoff and after landing that are necessary for flight and are accomplished prior to and following taxi operations, but to which flying time is not allocated. They consist of such events as preflight planning, completing forms, inspecting aircraft, and verifying flight readiness by actuating subsystems.
2. Pre-Takeoff Taxi. Consists of moving the aircraft under its own power from the parking area to the takeoff run-up area preparatory to taking off. It begins with the application of power in the parking area and ends when the aircraft is lined up on the runway for takeoff.
3. Takeoff. Consists of the takeoff roll, rotation for lift off, and lift off. It begins with the lineup check and ends when the aircraft reaches climb airspeed and includes required corrections for crosswind effect.

Takeoff (TTB):

Rolling Takeoff. A single aircraft takeoff which begins on the taxiway with receipt of taxi clearance and ends with a stabilized climb attitude; aircraft does not stop on the runway for engine runup.

4. Formation Takeoff. Takeoff, where two or more aircraft are taking off simultaneously from a single runway maintaining a predetermined position and pattern relation to one another. As in the normal takeoff, the formation takeoff begins with lineup check and is completed when aircraft reaches climb airspeed. It includes takeoff roll, rotation for lift off, and lift off.

Formation Takeoff (TTB) includes:

Minimum Interval Takeoff. A takeoff by a succession of aircraft from a single runway with minimum time separation between them.

5. Climb/Level Off. Consists of climbing aircraft to a given altitude and configuring it for level flight at that altitude. It begins when the climb airspeed is reached and ends when altitude, airspeed, heading, and power settings are stabilized at the selected altitude. It includes post-takeoff actions such as configuring the aircraft for

climb, interception of the proper climb schedule and configuring and trimming for straight-and-level flight at the proper altitude.

6. Descent/Approach. Consists of descending the aircraft from its cruising or working altitude using either contact or instrument procedures, to either a landing or another cruising altitude. It begins when the preparation for descent is initiated and ends when the flare for landing is initiated or level off is effected at the new altitude. It includes pre-descent configuration and the traffic pattern itself, or an approach and final approach. This includes low altitude instrument approaches. It also includes missed approaches and time spent in closed traffic.
7. Landing. Transitioning the aircraft from airborne flight to ground operations. It begins with the landing flare and ends at the end of the landing roll. It includes the flare, touch down and roll out, and required corrections for crosswind effects.
8. Post Landing Taxi. Consists of moving the aircraft under its own power from one point to another on the airfield after completion of landing roll out. In general, only 5 minutes per sortie are allotted to taxi operations.
9. Basic Control. Maneuvers used for basic control of altitude, heading, airspeed, rate of climb/descent, and rate of turn. They begin when the first deviation in altitude, heading, airspeed, or rate of climb or descent is initiated for the purpose of training in this mode of flight. They end subsequent to the last deviation when the airspeed, altitude and heading are stabilized at desired cruise, climb or descent values. They consist of normal turns, descents, climbs, changes in heading, airspeed or altitude. This includes contact and instrument maneuvers.
10. Precision Control. Maneuvers practiced to develop precision coordination and rate changes in attitude, airspeed, heading and altitude. They begin when the area is visually cleared prior to entry in the first maneuver or upon deviation from a previous stabilized condition of flight and end when airspeed, heading and altitude are stabilized at the selected attitude following completion of the last maneuver. They consist of such maneuvers as the maximum performance climbing turn, "Lazy Eight", Vertical "8" maneuvers, steep turns, etc.
11. Stall Recognition and Recovery Maneuvers. Maneuvers practiced by the student for the purpose of recognizing the onset of stall, corrections and learning the techniques for recovery therefrom. They begin when the student initiates airspace clearance procedures prior to initiation of the first stall maneuver and end when the airspeed, altitude and heading are stabilized at the desired attitude upon completion. They consist of power on, power off, accelerated, characteristic, and landing stalls.

TTB. Maneuvers practiced for the purpose of recognizing the approach to a stall and learning the techniques for recovery.

12. Aerobatics. Maneuvers in which the aircraft is maneuvered through all of its axes at varying airspeeds for the purpose of instilling confidence, and learning control techniques for the aircraft in all attitudes and at all airspeeds. They begin with the initiation of airspace clearance procedures prior to entering the first maneuver and are completed when the altitude, airspeed and headings are stabilized at the desired attitude following the final maneuver. They consist of Barrel Rolls, Aileron Rolls, Loops, Split "Ss", Immelmans, Cuban "8s", and Cloverleafs.
13. Unusual Attitude Recovery Maneuvers. Maneuvers which are utilized to regain attitude and airspeed control from unusual or vertical flight attitudes without stalling or overstressing the aircraft. They begin when the aircraft is placed in an unusual attitude by the instructor and are completed when the student has stabilized the aircraft in straight-and-level flight. They consist of instrument and contact high and low speed vertical, and spiral maneuvers.
14. Pilotage/Dead Reckoning Navigation. Navigation without any radio aids. It consists of pilotage in which the aircraft is navigated from point to point by visual recognition of landmarks along the way, and dead reckoning in which a course and estimated time of arrival are computed, with visual recognition of the destination as the method of verification of arrival.
15. High/Low Altitude Navigation (Manual). Navigation accomplished by means of manual operation of the aircraft in which position of the aircraft is determined by ground-based navigational aids and/or air/ground-based radar. Includes bearing pointer only procedures.
16. Close Formation. Flight where two or more aircraft are flown in close proximity to each other in a predetermined pattern and fixed position under the common direction of a single leader. In the case of UPT aircraft, separation will be on the order of 3 feet wingtip to wingtip. This training includes join up and rendezvous techniques as well as position changes and interplane communications.

Close Formation (TTB): To include "cell" formation flying.

17. Trail Formation. A type of formation in which station keeping at a distance to the rear of another aircraft is maintained through visual contact. This will include the position used during the inflight refueling.
18. Communications. Operation of on-board communications equipment to accomplish intra-plane, air base, enroute, and tactical communications.

19. Spin Recognition and Prevention. Maneuvers practiced for the purpose of recognizing the onset of a spin, and the techniques and corrections needed for recovery therefrom.
20. Emergency Procedures Training. This training requirement encompasses contingency training for various aircraft malfunctions. Procedures will be standardized as near as possible to those employed in similar situations in operational usage, except when specific training aircraft procedures dictate otherwise.
21. Formation Landing. A landing performed simultaneously on a single runway by two aircraft while maintaining a fixed and predetermined position relative to each other. It begins at configuration for the landing and ends upon completion of the rollout.
22. Low Level Visual Navigation. Visual navigation accomplished at 1000 feet AGL or below. Consists of pilotage from point to point by visual recognition of landmarks, maintenance of enroute ETAs through air-speed adjustment and meeting a predetermined time-over-target.
23. Decision Making. The thinking processes that lead to the selection of one alternative from among a known set of response alternatives. These processes include the identification of the potential alternatives, prioritizing the alternatives, and the selection of the desired alternatives. The selection process may include computational and other logical operations for combining information.
24. Air Drop Fundamentals. Consists of aligning the aircraft with a pre-designated track from an IP to a designated target area and flying it along the track taking into account wind effect. The simulated drop is effected by the crew member acting as drop master or bombardier. Drops may be made visually or electronically. This training requirement satisfies the basic elements of navigation and crew coordination which are common between cargo and personnel drops and radar level bombing.
25. Radar Navigation. The theory and use of on-board airborne radar for weather avoidance and ground map navigation.
26. Crew Coordination. Interaction between crew members within the aircraft to accomplish required tasks.
27. Collision Avoidance. The theory and practice of avoiding mid-air collision through visual search techniques, understanding of Air Traffic Control procedures and recognition of traffic congestion points in local traffic.

#### 1.3.2 Logicon Assessment

Logicon has compiled a description of the total set of Tanker/Transport/Bomber undergraduate pilot training requirements. Air Force documentation and extensive Logicon interviews with military training staff, personnel,

instructors, and students were the data sources for this description. The training requirements consist of 22 general functions. Logicon identified 108 specific tasks within the 22 general functions.

The general functions are:

1. Ground Operations
2. Pre-Takeoff/Post Landing
3. Takeoff
4. Climb/Level Off
5. Basic Control
6. Instruments/Precision Control
7. Normal Flight Departure and Recovery
8. Radio Nav Aid Navigation
9. Cruise
10. Visual/Airborne Radar Navigation
11. Air Drop Fundamentals
12. Cell Formation
13. Trail Formation
14. Communications
15. Emergency Procedures
16. Asymmetrical Thrust
17. Crew Coordination
18. Checklist Usage, Pacing and Procedures
19. Decision Making
20. Collision Avoidance
21. Holding/Descent/Approaches
22. Landing

### 1.3.3 Logicon's Functions Defined

1. Ground Operations. All tasks accomplished before engine start and after engine shutdown. Includes such items as mission planning, oxygen and personal equipment use and inspection, use of maintenance forms, knowledge of regulations, and exterior and interior preflights and postflights.
2. Pre-Takeoff/Post Landing. Consists of starting engines and taxiing. It begins with the start engines checklist and ends at brake release for takeoff. Starts again after landing and ends upon completion of the engine shutdown checklist.
3. Takeoff. Consists of the takeoff roll and lift off/unstick. It begins with brake release and ends at lift off/unstick. It includes static, rolling, wet, max effort and MITO/formation takeoffs. Day and night.
4. Climb/Level Off. Consists of climbing aircraft to a given altitude and configuring it for level flight at that altitude. It begins with the first post-takeoff actions (climb checklist) which configures the aircraft for climb and ends with the aircraft trimmed and power set for straight and level flight on proper altitude and airspeed.
5. Basic Control. Maneuvers used to change airspeed, altitude and/or configuration of the aircraft. These maneuvers train the pilot to use drag devices (airbrakes, spoilers, speedbrakes, etc.), gear, flaps, slats, while making power and pitch changes to maintain the desired VVI, altitude and airspeed.
6. Instruments/Precision Control. Basic fundamentals, procedures and techniques necessary for safe and precise instrument flight. Maneuvers practiced to develop precision coordination and rate changes in airspeed, heading and altitude. Consists of steep turns, slow flight, constant rate/airspeed climbs and descents with turns. This is just basic instrument training. In-depth instrument training is performed where it appears in the other training areas.
7. Normal Flight Departure and Recovery. Maneuvers practiced for the purpose of recognizing the onset of departure from normal flight and the techniques and corrections needed for recovery therefrom. They consist of high sink maneuvers, initial buffet, unusual attitudes, stall recognition and recovery, etc.
8. Radio Nav. Air Navigation. Navigation accomplished in which the position of the aircraft is determined by ground-based navigational aids, ground based radar and/or inertial guidance systems. Includes jet route navigation, TACAN fix-to-fix navigation and Victor airway navigation.
9. Cruise. Consists of duties prescribed during phases of flight not specifically covered in other areas. Consists of auto-pilot usage,

radar weather avoidance, global procedures, ADIZ procedures as well as maintenance of flight logs, systems operation and station checks.

10. Visual/Airborne Radar Navigation. Navigation without radio aids. It consists of pilotage in which the aircraft is navigated from point to point by visual recognition of landmarks, and dead reckoning in which a course and estimated time of arrival are computed with visual recognition of the destination as a method of verification of arrival. The visual and radar navigation are done in conjunction with each other and during both day and night.
11. Air Drop Fundamentals. Consists of aligning the aircraft with a pre-designated track from an IP to a designated target area and flying it along the track taking into account wind effect. The simulated drop is effected by the crew member acting as drop master or bombardier. Drops may be made visually or electronically. This training requirement satisfies the basic elements of navigation and crew coordination which are common between cargo and personnel drops and radar low level bombing. Day and night.
12. Cell Formation. A type of formation in which station keeping at a predetermined distance and position from another aircraft is maintained through visual and/or airborne radar contact. It includes cell departure and join-ups, rendezvous techniques as well as position changes. Day and Night.
13. Trail Formation. Flight where two aircraft are flown in close proximity to each other in a predetermined pattern simulating the position used during inflight refueling. Day and Night.
14. Communications. Operation of on-board communications (interphone, UHF, HF, and VHF) equipment to accomplish intra-plane, air base, en-route, and tactical communications.
15. Emergency Procedures. This training requirement encompasses contingency training for various aircraft malfunctions. Procedures will be standardized as nearly as possible to those employed in similar situations in operational usage, except when specific training aircraft procedures dictate otherwise. This also includes anti-hijacking procedures.
16. Asymmetrical Thrust. Consists of the understanding of minimum directional control speeds, performance and control problems, and the performance of maneuvers simulating engine failure during takeoff roll, unstick/rotation/liftoff, climb out, cruise, approach, landing and missed approaches. Day and night.
17. Crew Coordination. Interaction between crew members within the aircraft to accomplish required tasks. Coordination of information.
18. Checklist Usage, Pacing and Procedures. This training results in all checklist items and procedures required by the flight manual and

applicable directives being accomplished in a timely manner without deviations, omissions or errors.

19. Decision Making. The thinking processes that lead to the selection of one alternative from among a known set of response alternatives. These processes include the identification of the potential alternatives, prioritizing the alternatives and the selection of the desired alternatives. The selection process may include computational and other logical operations for combining information.
20. Collision Avoidance. The theory and practice of avoiding mid-air collision through visual search techniques, understanding of Air Traffic Control procedures, and recognition of traffic congestion points in local traffic. Operation of a collision avoidance system.
21. Holding/Descent/Approaches. Consists of holding patterns and descending the aircraft from its cruising or working altitude using published procedures to another cruising altitude or to effect an approach. It begins when the preparation for descent is initiated and ends when the flare for landing is initiated or level off is effected at the new altitude. It includes predescent configuration and the traffic pattern itself, or an approach and final approach. This includes low altitude instrument approaches, both precision and non-precision. It also includes missed approaches and closed traffic operations.
22. Landing. Transitioning the aircraft from airborne flight to ground operations. It begins with the landing flare and ends at the completion of the landing roll. It includes the flare, touch down, and roll out, and required corrections for crosswind effects, short field operations, thrust reversal and touch-and-go landings.

#### 1.3.4 Comparison of Requirements

The Future Undergraduate Pilot Training (FUPT) requirements derived by Logicon are not a duplicate of the 27 FUPT requirements. In Table 1-1 a comparison is drawn between the 27 intercommand requirements and the 22 drawn up by Logicon. Where differences are found they are explained in the right hand column of the table.

#### 1.3.5 Specific Tasks

The Training Requirements (specific tasks) which comprise the 22 general functions are given below. These are the general functions and specific tasks.

1. Ground Operations
  - a. Personal Equipment
  - b. Maintenance and Operations Forms
  - c. Preflight Exterior Inspection

TABLE I-1. A COMPARISON OF ASSESSMENTS

ATC Inter-Command UPT Conference 27 FUPT Training Requirements	Logicon's 22 TTB Training Requirements	Reason for Differences
1. Ground Operations 2. Pre-Takeoff Taxi 3. Takeoff 4. Formation Takeoff (1) 5. Climb/Level Off 6. Descent/Approach 7. Landing 8. Post Landing Taxi (11) 9. Basic Control 10. Precision Control 11. Stall Recognition and Recovery 12. Aerobatics (111) 13. Unusual Attitude Recovery (1v) 14. Pilotage/Dead Reckoning Navigation 15. High/Low Altitude Navigation (Manual) 16. Close Formation 17. Trail Formation 18. Communications 19. Spin Recognition and Prevention (v) 20. Emergency Procedures 21. Formation Landing (vi) 22. Low Level Visual Navigation (vii) 23. Decision Making 24. Air Drop Fundamentals 25. Radar Navigation 26. Crew Coordination 27. Collision Avoidance	1. Ground Operations 2. Pre-Takeoff/Post Landing 3. Takeoff 4. Climb/Level Off 21. Holding/Descent/Approaches 22. Landing 5. Basic Control 6. Instruments/Precision Control 7. Normal Flight Departure and Recovery 10. Visual/Airborne Radar Navigation 8. Radio Nav Aid Navigation 12. Cell Formation 13. Trail Formation 14. Communications 15. Emergency Procedures 10. Visual/Airborne Radar Navigation 19. Decision Making 11. Air Drop Fundamentals 10. Visual/Airborne Radar Navigation 17. Crew Coordination 20. Collision Avoidance 9. Cruise (viii) 16. Asymmetrical Thrust (ix) 18. Checklist Usage, Pacing and Procedures (x)	<p>NOTE: The numbers are different in that Logicon used a phase of flight approach.</p> <p>(1) 4. <u>Formation Takeoff</u>. Deleted, as it is not done in TTB aircraft. HTO Takeoffs included as a task along with static, rolling and water takeoffs under requirement 3, Takeoff.</p> <p>(11) 8. <u>Post Landing Taxi</u>. Deleted as a separate requirement. This is described as moving the aircraft under its own power from one point to another on the airfield. Logicon included this under requirement 1, Ground Operations.</p> <p>(111) 12. <u>Aerobatics</u>. Deleted, can do in primary but not a need-to-do in basic training.</p> <p>(1v) 13. <u>Unusual Attitude Recovery</u>. Deleted as a separate requirement. In AFM 51-37 this task is under basic instrument flying. Logicon, after much thought, made it a task under 7, Normal Flight Departure and Recovery. Logicon did not retain as a separate requirement since contact and spiral instrument maneuvers were deleted.</p> <p>(v) 19. <u>Spin Recognition and Prevention</u>. Deleted from the training program. Stall recognition and recovery is taught.</p> <p>(vi) 21. <u>Formation Landing</u>. Deleted. This requirement is described as two aircraft landing simultaneously on a single runway. Not a need-to-do for TTB pilots.</p> <p>(vii) 22. <u>Low Level Visual Navigation</u>. Deleted. This requirement is covered under requirements 14 and 24.</p> <p>(viii) 9. <u>Cruise</u>. Added to cover duties prescribed during phases of flight not specifically covered in other areas. Flight logs, systems operations, station checks, etc.</p> <p>(ix) 16. <u>Asymmetrical Thrust</u>. Added. Study showed this to be an important training requirement.</p> <p>(x) 18. <u>Checklist Usage</u>. Added. Study showed this to be an important training requirement.</p>

- d. Preflight Interior Inspection
- e. Postflight Interior Inspection
- f. Postflight Exterior Inspection
- g. Mission Planning
- h. Regulations
- i. Aircraft Limitations
- 2. Pre-Takeoff/Post Landing
  - a. Engine Start — Cartridge
  - b. Engine Start — Pneumatic
  - c. Reverse Taxi
- 3. Takeoff - Day and Night
  - a. Static
  - b. Rolling
  - c. Water Augmented
  - d. Crosswind Crab
  - e. Max. Effort/Obstacle Clearance
  - f. MITO (minimum interval takeoff)
- 4. Climb/Level Off
  - a. Instrument Departure
- 5. Basic Control
  - a. Airbrake Usage
  - b. Trim Usage
  - c. Flap Usage
  - d. Slat Usage
  - e. Gear Usage
  - f. Flight Controls

6. Instruments/Precision Control
  - a. Control Instruments
  - b. Performance Instruments
  - c. Navigation Instruments
  - d. Instrument Cross-check
  - e. Instrument Cross-check Analysis
  - f. Navigation Procedures  
(As described in AFM 51-37, Chap. 2, Section E)
  - g. Steep Turns
  - h. Vertical "S"
7. Normal Flight Departure and Recovery
  - a. Initial Buffet/Stall Recognition (Pwr on/off, Flaps up/dn)
  - b. High Sink Maneuver
  - c. Slow Flight
  - d. Unusual Attitudes (Simulator)
8. Radio Nav Aid Navigation
  - a. Jet Route Navigation
  - b. TACAN Fix-to-Fix Navigation
  - c. Victor Airways Navigation
9. Cruise
  - a. Auto-pilot Usage
  - b. Radar Weather Avoidance
  - c. Global Procedures
  - d. ADIZ Procedures
  - e. Oxygen Usage
10. Visual/Air-Based Radar Navigation - Day and Night
  - a. Pilotage/DR

- b. Radar Ground Mapping
  - c. Terrain Avoidance Radar
  - d. Electro-optical Viewing System
  - e. Entry and Exit
11. Air Drop Fundamentals - Day and Night
- a. Pilotage/DR
  - b. Instruments (BDI/TG)
12. Cell Formation - Day and Night
- a. Departure and Join-up
  - b. Enroute
  - c. Position Changes
  - d. Rendezvous
13. Trail Formation - Day and Night
- a. Lead
  - b. Receiver
  - c. Breakaways
14. Communications
- a. Interphone
  - b. UHF Operation
  - c. HF Operation
  - d. VHF Operation
  - e. Intra-plane
  - f. Ground/Tower
  - g. Enroute
  - h. Tactical
  - i. Departure/Approach

15. Emergency Procedures
  - a. Flaps up Approach and Landing
  - b. Emergency Descent
  - c. Anti Hi-jacking
  - d. Slats Only Landing
  - e. Crash Landing/Ditching
16. Asymmetrical Thrust - Day and Night
  - a. Takeoff
  - b. Trail Formation
  - c. Approaches
  - d. Missed Approaches
  - e. Landings
17. Crew Coordination
18. Checklist Usage, Pacing and Procedures
19. Decision Making
  - a. Judgment
  - b. Directive Compliance
20. Collision Avoidance
  - a. Visual
  - b. Collision Avoidance System
21. Holding/Descent/Approach
  - a. Holding Pattern (High)
  - b. Holding Pattern (Low)
  - c. Enroute Descent
  - d. Published Penetrations
  - e. VFR Traffic Pattern

- f. PAR Approach
  - g. ILS Approach
  - h. ASR Approach
  - i. TACAN Approach
  - j. VOR Approach
  - k. ADF Approach
  - l. VOR/DME
  - m. Localizer
  - n. Back Course Localizer
  - o. Circling Approach
  - p. Coupled ILS Approach
  - q. VOR Procedures
  - r. TACAN Procedures
  - s. ILS Procedures
  - t. ADF Procedures
22. Landing - Day and Night
- a. Full Stop
  - b. Touch and Go
  - c. Crosswind
  - d. Short Field Operations
  - e. Drag Chute Operation

#### 1.3.6 Objectives

AFM 50-2 states that objectives can be specified at different levels. Objectives can be specified for: the basic skills and knowledges; the more complex skills which represent combinations of the basics; and the application of these skills and knowledges in actual situations. At this time, the objectives must be written at the functional level. Using the feedback and interaction loop of the ISD process, the objectives can be refined to the basic tasks after the decision is made to develop a dual track (TTB/FAR) UPT. If implemented, what proficiency level to teach at UPT must also be

decided. Conditions and standards will need to be revised after the training and testing media (including the training aircraft) have been identified.

Considering conditions as they relate to objectives: In a two seat aircraft where all students are checking out in the left seat, it is difficult to get a qualified, unbiased occupant of the right seat.

The right seat will most likely be filled by an IP and a good copilot can get almost anyone through a pilot check. On the other hand, a bad error on the part of the copilot, or no support when needed, could doom the evaluatee to failure. Grading becomes very subjective under these conditions. A performance measurement system (PMS) on the state-of-the-art simulator with controllable conditions would allow for much more objective evaluations.

Course training standards for the Inter-Command future training requirements are listed in Appendix C of the DCS 1 Operations, HQ ATC Report, "Comparison of UPT - Generalized vs. Specialized," dated 5 March 1976. For the training requirements not listed by that report, but identified by Logicon as needed for a complete catalogue, the objectives are shown in the following table.

<u>Conditions</u>	<u>Performance</u>	<u>Standards</u>
<u>CREW COORDINATION</u>		
In the aircraft, during ground operations and while flying a complete mission profile.	*Coordinate with the other crew members during all phases of the mission.	As required by the flight manual and other governing directives, without omission, deviation, or error and causing no delays or confusion by any crew member.
*For a goal analysis of "coordinate," see Appendix B, page 118.		
<hr/>		
<u>CRUISE</u>		
In the simulator during a 15 minute cruise leg.	Complete a flight manual check. Make complete entries in Flight Log Form 200 required by the Flight Manual and ATC Mission Log 1-1.	All items must be accomplished within the 15 minute time frame with no deviations, omissions or errors.

### CRUISE (cont)

From Memory	Write the ten global procedures and 5 ADIZ procedures listed in the ATC Manual 1-1.	Without loss of the directives' intent.
Given a list of all auto-pilot controls, switches and indicators in the PTT.	Locate and identify each listed item and state its function.	In two minutes without error.

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### CHECKLIST USAGE, PACING AND PROCEDURES

In the simulator during ground and flight simulation of a complete mission profile using the pilot's abbreviated check	Accomplish all pilot procedures and checklist items required by the flight manual and applicable directives.	Without deviations, omissions, or errors. All items must be completed in sequence and in a timely manner which does not detract from the efficient and safe conduct of the mission.
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### ASYMMETRICAL THRUST

<u>Conditions</u>	<u>Performance</u>	<u>Standards</u>
In the Flight Simulator	Fly the aircraft at and after engine loss occurring during: Takeoff Roll (above S1 speed) Unstick Air Refueling Climb Approach Missed Approach	Maintaining positive control. No deviations in establishing or maintaining the proper aircraft attitude, altitude, and airspeed during the maneuver being performed. Techniques for directional, lateral and pitch control and power management applied in accordance with the flight manual.
Given 10 performance problems and the performance section of the Flight Manual.	Compute the minimum directional control speeds (IAS).	Within 2 knots IAS per problem and (one minute per problem) 10 minutes.

## CHAPTER 2

### MAC/SAC COMMONALITIES

#### 2.1 BACKGROUND AND DISCUSSION

Subtask 1.2 requires the identification of the common tasks performed by B-52, KC-135, C-141, C-9, C-5, and C-130 pilots. Some further background information is given below, together with a closer examination of the concept of commonality and a preview of the benefits question.

The current UPT program is called a generalized training approach. All students train in the same pilot skills to the same performance standards. The objective is to produce a universally assignable pilot. However, ATC's Report No. 77-4, Operations Analysis, Nov. 1977 states "the current generalized UPT program and assignment policy does not produce a universally assignable pilot." Logicon feels a similar situation could arise following SUPT if the term specialized training is not examined carefully.

In this contract, Logicon has not studied the FAR track. After our study of the TTB track, however, and by referencing ISD methodology, we feel that the term specialized training may be a misnomer. There are vast differences between commands, aircraft differences within the commands, and different missions performed in the same aircraft. The TTB aircraft and missions are comprised of turboprops and jets; some refuel as receivers, one as a tanker, and some not at all. Some use Automatic Direction Finding (ADF), and some don't even have ADF. The C-130 mainly flies the low altitude structure but most aircraft don't. One aircraft flies low level using radar terrain avoidance; two others fly low level by mostly visual navigation and two do no low level operation. The flight controls are vastly different and one aircraft uses the FD 109 instrument system. One aircraft has no ailerons, some have slats and flaps, some just flaps, some have thrust reverse, one reverse props, and one a drag chute. Some use nose wheel steering and one doesn't even have a nose wheel. In analyzing the system requirements for the TTB aircraft we found a varied list of job tasks being done with different equipment under different conditions and performed to different standards.

All of these differences indicate that the TTB track, as now contemplated, will not really be as specialized as the word might imply. While there are commonalities between MAC and SAC, and while there will be benefits to SUPT, the concepts of commonality and specialized training should be examined in more detail.

Recognizing the differences between the aircraft, the next logical step is the identification of commonalities between aircraft rather than between commands. A first guide to this kind of identification is found in table 1-2.

Except for mission differences, there would be 100% commonality (indicated by a C) in each of the diagonal entries of the table. There would be different degrees of commonality (indicated by Xs) in each of the other ten non-redundant cells of the table.

TABLE 1-2. COMMONALITY TABLE

	B-52	KC-135	C-130	C-141	C-9	C-5
B-52	C	X	X	X	X	X
KC-135		C	X	X	X	X
C-130			C	X	X	X
C-141				C	X	X
C-9					C	X
C-5						C

In order for the commonality term of the benefits equation (presented in Section 3, Chapter 3), to be more precise, there should be an analysis of the more detailed commonalities as indicated above, together with various assumptions about pilot assignments and transfers between aircraft. Then the more precise commonality term would permit greater precision in benefit studies.

## 2.2 METHOD OF DATA COLLECTION AND ANALYSIS

The determination of training requirements common to MAC and SAC necessitated obtaining information from a variety of sources. Interviews were conducted with MAC and SAC instructors and staff, questionnaires administered to beginning and advanced students and instructors. MAC and SAC training and evaluation manuals were reviewed. Training requirements noted in the manuals were compared and contrasted with responses to the interviews and questionnaires. For example, student and instructor input was helpful in estimating the actual degree of commonality among tasks which appeared common on the surface. This input was also helpful in determining deviations in emphasis and content of course materials between major commands and between the manuals and actual course conduct. These efforts resulted in a list of common functions and tasks.

Training resource requirements associated with the common functions and tasks are based on current definitions of training devices and on derived definitions of other resources, such as classrooms and learning centers. Thus, each training resource requirement is referenced to an existing class or type of training resource. Reference is made to the projected TTB training aircraft. It was not used in the estimates of training resource requirements, since the need for an appropriate UPT training aircraft in the TTB track is generally understood. However, it is included in the list of training resources for the sake of completeness.

Estimates of the extent to which the common tasks could be trained on existing commercial and military simulators are based on proficiency level

indices. These indices were derived from Air Force training, ISD and Stan/Eval proficiency standards which were reviewed and then rewritten to make them more specific to the present application. Thus, extent of training is defined in terms of expected level of proficiency.

## 2.3 RESULTS

This subsection describes the training requirements which are common to MAC and SAC. It also provides supplementary information of two types. The first is an estimate of the resources necessary to support UPT training of the common requirements in a dual track program. The second is an estimate of the extent to which current resources could be used to achieve the training requirements. Estimates of trainability have been provided for current commercial and military simulators as well as for Air Force simulators and other training devices.

### 2.3.1 Commonality of Training Functions/Tasks

Subtask 1.2 in the SOW calls for the identification of TTB pilot training tasks which are common to SAC and MAC. An ideal definition of commonality would apply to different aircraft as well as different commands. The two SAC aircraft represented in the study show less commonality between themselves than do some of the MAC aircraft. Likewise, the four MAC aircraft diverge among themselves, yet show some commonalities with SAC.

To identify commonalities entails conducting a task similarity analysis to determine whether the behavior required to perform the task is sufficiently similar (in the six aircraft studied) to warrant its consideration as a single task for training purposes. The practical number of pilot tasks which are common is limited by the specialized missions and aircraft differences. Most of the 22 functions are superficially common to the six aircraft, but much of the commonality is lost when more detailed task levels are considered. In the following list of training tasks, X's appear under all six aircraft, indicating which tasks are performed in each aircraft. Lesser degrees of commonality (e.g., involving tasks performed in three of the six aircraft) could be considered. However, as a practical definition of commonality, the study required the task to be common to all six aircraft. Many of these tasks need to be taught in UPT, regardless of the training track or aircraft being flown. Examples of procedures and operations which are common for all aircraft, and needed for both tracks, are ILS procedures, decision making, collision avoidance, holding pattern, VOR procedures and ground operations. Training tasks such as regulations and aircraft limitations would not be affected by a dual track training program since they also are common to any type of UPT training. Aircraft limitations must be learned, but are different for each plane being flown, and regulations must be taught for the command owning the plane and conducting the training as well as for the Air Force.

Of the training requirements identified for the TTB track of UPT, all are need-to-know or -do items; however, only a few need be taught in a multi-engine trainer. All items are considered essential for training, but most can be taught in either a CCTS or at UPT. The functions identified by this

study are the ones which cannot be taught in the T-38 or can be better taught in the Next Generation Trainer.

According to this reasoning, the functions which, realistically, seem to have the most commonality, and are not now being taught in UPT, are:

Cruise

Asymmetrical Thrust

Crew Coordination

Checklist Usage, Pacing and Procedures

Table 1-3 indicates the commonality of training requirements based on the same or similar tasks being performed in each aircraft type.

### 2.3.2 Resource Requirements and Extent of Trainability

This subsection of the interim report (1) identifies the training resource requirements of training functions/tasks common to MAC and SAC and (2) provides estimates of whether and to what extent these tasks can be accomplished in current military or commercial flight simulators.

2.3.2.1. Resource Requirements. After identifying the functions/tasks common to TTB, the next step was to identify and define general categories of training resources appropriate to Air Force flight training. These categories serve as a pool of resource requirements possibilities, and are listed below:

1. Classroom (C). Refers to general lecture, discussion, question-and-answer type of instruction typically associated with the classroom.
2. Mediated classroom (MC). Refers to general lecture or discussion material which may be mediated with, or augmented by, sound/slide, videotape, closed-circuit TV or other instructional media appropriate to the classroom.
3. Learning Center (LC). Refers to all classes of instructional media and materials which may be conveniently located for student use on an as-needed basis. Would provide the student with remedial or self-paced learning possibilities and would not require instructor assistance to use. Could potentially include learning carrels, videotape, sound/ slide, etc., as well as any of the following resources not requiring instructor assistance.
4. Part Task Trainers (PTT). Training devices which permit selected aspects of a task to be trained to a high skill level. These selected aspects of the task may be trained in isolation from other aspects of the same task and/or in isolation from other tasks.

TABLE 1-3. COMMONALITY OF TRAINING REQUIREMENTS

COMMONALITIES		AIRCRAFT					
		(X indicates the task is performed)					
Training Requirements		B-52	KC-135	C-141	C-130	C-9	C-5
1.	Ground Operations						
A.	Personal equipment	X	X	X	X	X	X
B.	Maintenance and Ops. forms	X	X	X	X	X	X
C.	Preflight exterior inspection	X	X			X	
D.	Preflight interior inspection	X	X	X	X	X	X
E.	Postflight interior inspection	X	X	X	X	X	X
F.	Postflight exterior inspection	X	X			X	
G.	Mission planning	X	X	X	X	X	X
H.	Regulations	X	X	X	X	X	X
I.	Aircraft Limitations	X	X	X	X	X	X
2.	Pre-Takeoff/Taxi						
A.	Engine start-cartridge	X	X				
B.	Engine start-pneumatic	X	X	X	X	X	X
C.	Reverse taxi			X	X		
D.	Engine runup				X		
3.	Takeoff - Day and Night						
A.	Static		X	X	X	X	X
B.	Rolling	X	X	X	X	X	X
C.	Wet	X	X				
D.	Crosswind crab	X					X
E.	Max effort/obstacle clearance			X	X	X	X
F.	MITO	X	X	X	X		
G.	Reduced power			X	X	X	X
4.	Climb/Level Off						
A.	Instrument departure - SID	X	X	X	X	X	X
5.	Basic Control						
A.	Airbrake usage	X	X	X		X	
B.	Trim usage	X	X	X	X	X	X
C.	Flap usage	X	X	X	X	X	X
D.	Slat usage					X	X
E.	Gear usage	X	X	X	X	X	X
F.	Flight controls	X	X	X	X	X	X
G.	Thrust reversers			X	X	X	X
6.	Instruments/Precision Control						
A.	Control instruments	X	X	X	X	X	X
B.	Performance instruments	X	X	X	X	X	X
C.	Navigation instruments	X	X	X	X	X	X
D.	Instrument cross-check	X	X	X	X	X	X
E.	Instrument cross-check analysis	X	X	X	X	X	X
F.	Navigation procedures (as described in AFM 51-37, Chap 2, Sec E)	X	X	X	X	X	X
G.	Steep turns	X	X	X	X	X	X
H.	Vertical "S"	X	X	X	X		X

TABLE 1-3. COMMONALITY OF TRAINING REQUIREMENTS (Cont)

<u>COMMONALITIES</u>		<u>AIRCRAFT</u>					
		(X indicates the task is performed)					
<u>Training Requirements</u>		B-52	KC-135	C-141	C-130	C-9	C-5
7. Normal Flight Departure and Recovery							
A. Initial buffet/stall recognition (PWR on/off, FLAPS up/dn)		X	X	X	X	X	X
B. High sink maneuver				X	X	X	X
C. Slow flight				X	X	X	X
D. Unusual attitudes (simulator)		X	X	X	X	X	X
8. Radio Nav Aid Navigation							
A. Jet route navigation			X	X	X	X	X
B. TACAN fix-to-fix navigation		X	X	X	X	X	X
C. Victor airways navigation				X	X	X	X
9. Cruise							
A. Auto-pilot usage		X	X	X	X	X	X
B. Radar weather avoidance			X	X	X	X	X
C. Global procedures		X	X	X	X	X	X
D. ADIZ procedures		X	X	X	X	X	X
E. Oxygen usage		X	X	X	X	X	X
10. Visual/Airbased Radar Navigation - Day and Night							
A. Pilotage/DR		X		X	X	X	X
B. Radar ground mapping				X	X		X
C. Terrain avoidance radar		X					
D. Electro-optical viewing system		X					
E. Entry and exit		X		X	X		X
11. Air Drop Fundamentals - Day and Night							
A. Pilotage/DR		X		X	X		X
B. Instruments (FCI/TG)		X		X	X		X
12. Cell Formation - Day and Night							
A. Departure and join-up		X	X	X	X		X
B. Enroute		X	X	X	X		X
C. Position changes		X	X	X	X		X
D. Rendezvous		X	X	X	X		X
13. Trail Formation - Day and Night							
A. Lead			X	X	X		X
B. Receiver		X	X	X			X
C. Breakaways		X	X	X	X		X

TABLE 1-3. COMMONALITY OF TRAINING REQUIREMENTS (Cont)

COMMONALITIES (Continued)	AIRCRAFT					
	(X indicates the task is performed)					
Training Requirements	B-52	KC-135	C-141	C-130	C-9	C-5
14. Communications						
A. Interphone	X	X	X	X	X	X
B. UHF operation	X	X	X	X	X	X
C. HF operation	X	X	X	X	X	X
D. VHF operation	X	X	X	X	X	X
E. Intra-plane	X	X	X	X	X	X
F. Ground/tower	X	X	X	X	X	X
G. Enroute	X	X	X	X	X	X
H. Tactical	X	X	X	X	X	X
I. Departure/Approach	X	X	X	X	X	X
15. Emergency Procedures						
A. Flaps up approach and landing	X	X	X	X	X	X
B. Emergency descent	X		X	X	X	X
C. Anti-hijacking	X	X	X	X	X	X
D. Slats only landing					X	X
E. Crash landing/ditching	X	X	X	X	X	X
16. Asymmetrical Thrust - Day and Night						
A. Takeoff	X	X	X	X	X	X
B. Trail formation	X	X	X	X	X	X
C. Approaches	X	X	X	X	X	X
D. Missed approaches	X	X	X	X	X	X
E. Landings	X	X	X	X	X	X
17. Crew Coordination	X	X	X	X	X	X
18. Checklist Usage, Pacing and Procedures	X	X	X	X	X	X
19. Decision Making						
A. Judgment	X	X	X	X	X	X
B. Directive compliance	X	X	X	X	X	X
20. Collision Avoidance						
A. Visual	X	X	X	X	X	X
B. Collision avoidance system						

TABLE 1-3. COMMONALITY OF TRAINING REQUIREMENTS (Cont)

COMMONALITIES		AIRCRAFT					
		(X indicates the task is performed)					
	Training Requirements	B-52	KC-135	C-141	C-130	C-9	C-5
21.	Holding/Descent/Approach						
A.	Holding pattern (high)	X	X	X	X	X	X
B.	Holding pattern (low)			X	X	X	X
C.	Enroute descent	X	X	X	X	X	X
D.	Published penetrations	X	X	X	X	X	X
E.	VFR traffic pattern	X	X	X	X	X	X
F.	PAR approach	X	X	X	X	X	X
G.	ILS approach	X	X	X	X	X	X
H.	ASR approach	X	X	X	X	X	X
I.	TACAN approach	X	X	X	X	X	X
J.	VOR approach	X	X	X	X	X	X
K.	ADF approach			X	X	X	X
L.	VOR/DME	X	X	X	X	X	X
M.	Localizer	X	X	X	X	X	X
N.	Back course localizer	X	X	X	X	X	X
O.	Circling approach	X	X	X	X	X	X
P.	Coupled ILS approach	X	X	X	X	X	X
Q.	VOR procedures	X	X	X	X	X	X
R.	TACAN procedures	X	X	X	X	X	X
S.	ILS procedures	X	X	X	X	X	X
T.	ADF procedures	X		X	X	X	X
U.	Radar procedures			X	X	X	X
22.	Landing - Day and Night						
A.	Full stop	X	X	X	X	X	X
B.	Touch and go's	X	X	X	X	X	X
C.	Crosswind	X	X	X	X	X	X
D.	Reverse prop				X		
E.	Short field operations			X	X	X	X
F.	Thrust reverse			X		X	X
G.	Drag chute operation	X					

5. Cockpit Familiarization Trainer (CFT). Training devices incorporating facsimiles of the flight stations of the respective aircraft. Controls, instruments, switches, and lights are accurately located and realistic in appearance to allow the student to familiarize himself with the cockpit layout. CFT may also be used for the practice of repetitive tasks such as checklists and the performance of normal and emergency procedures. Controls, switches, and instruments are not (necessarily) activated for response to student inputs.
6. Cockpit Procedures Trainer (CPT). Training devices used to transition aircrews into designated and/or different aircraft. CPTs are used for both cockpit familiarization and procedures training in normal, alternate and emergency procedures. For high transfer procedures training, switches and instruments must be activated to respond appropriately to student inputs. Dynamic simulation of all cockpit functions is not required.
7. Instrument Flight Trainer (IFT). General purpose training devices with active controls, switches, and instruments which dynamically simulate flight characteristics. IFTs are used for training instrument flight procedures, navigation procedures, communications and other higher level flying skills. IFTs may or may not have motion bases but do not have visual systems for the cockpit, i.e., T-40.
8. Flight Simulators (FS). A special purpose trainer with active controls, switches and instruments which dynamically simulates the flight characteristics of the specific aircraft for which it was designed. Flight simulators are used for training a variety of higher level flying skills which includes some proportion of the emergency procedures. Current FSs typically are equipped with a motion base (up to 6 degrees) and visual systems which represent all or selected portions of the training flight.
9. Weapon System Trainer (WST). A training device which incorporates the characteristics of the FS with the capabilities to simulate salient features of the tactical environment to provide both a synthetic flight and tactics environment. The WST functions in either an independent or integrated mode to provide individual or team training. Both individual and crew-coordinated skills can be trained to a high level of proficiency. WSTs may include both visual and motion systems and may provide partial or full mission capability.
10. TTB Training Aircraft (TTB A/C). A trainer aircraft built to support TTB training. Capabilities of the aircraft would include producing or simulating asymmetric thrust.

Next, it was necessary to match each of the common functions and tasks listed in the previous subsection with the appropriate resource requirements. This step required a review of the characteristics of each task in order to produce appropriate matching. Both subject matter and training expertise were employed in the process, which considered such factors as task difficulty, approximate level of proficiency required, crew coordination of the

task (if any), etc. It also considered the most cost-effective means of training the task; for example, if the task could be adequately trained in a low cost procedures or familiarization trainer, a simulator is not necessarily required. Additional information was obtained from the questionnaires and interview forms regarding how these tasks are currently trained. Table 1-4 shows each of the functions/tasks as it is matched with its identified resource requirements.

2.3.2.2 Trainability. Subtask 1.2 also required the making of estimates of whether, and to what extent, common training tasks can be accomplished in current military or commercial flight simulators. Preliminary steps for accomplishing this item were the identification of common tasks and the definition of training resource requirements which included current commercial/military flight simulators. It is already noted in the preceding paragraphs which common tasks may be trained in which resources. To answer the question of extent of training derived, it was decided to use the expected level of proficiency which could be obtained on each function/task in currently available simulators.

Various existing and suggested Air Force proficiency codes were reviewed in an effort to define appropriate proficiency levels. The levels selected for present purposes attempted to retain the best features of those reviewed and, at the same time, to provide reasonably clear and simple indications of extent of training expected from current simulators. Four levels, representing an ordinal scale of proficiencies, were ultimately selected. These are:

- Level 1 - Unable to perform complete task. Able to visualize or understand only portions of the task.
- Level 2 - Unable to perform complete task. Able to visualize or understand complete task.
- Level 3 - Able to perform task but with limited proficiency. Less than operational standard attained.
- Level 4 - Able to perform task to operational standards. Additional training not required. Commands may demand evaluation in the aircraft, but training would not be required.

To comply with contractual requirements regarding current military or commercial flight simulators, three general categories of training devices were selected from the list of training resources in the preceding subsection. These are:

1. IFT. These instrument trainers previously represented state-of-the-art in simulation technology, and were often referred to as flight simulators. With advancing state-of-the-art, these IFTs are being down-graded to the status of trainers as opposed to simulators. In fact, they often serve both functions, since they possess limited simulation capabilities as well as those of the less sophisticated devices.

TABLE 1-4. TRAINING RESOURCE REQUIREMENTS

Function/Task (F/T)	C	MC	LC	PTT	CFT	CPT	IFT	FS	WST	A/C
(F) Cruise										
(T)Auto-pilot usage	X	X	X	X	X	X		X	X	X
(T)Radar weather avoidance	X	X	X	X				X	X	
(T)Global Procedures	X	X	X				X	X	X	X
(T)ADIZ Procedures	X	X	X				X	X	X	X
(T)Oxygen Usage	X	X	X	X	X	X		X	X	X
(F) Asymmetrical Thrust										
(T)Takeoff	X	X	X				X	X	X	X
(T)Trail Formation	X	X	X					X	X	X
(T)Approaches	X	X	X				X	X	X	X
(T)Missed Approaches	X	X	X				X	X	X	X
(T)Landings	X	X	X					X	X	X
(F) Crew Coordination	X	X	X			X		X	X	X
(F) Checklist Usage, Pacing & Procedures	X	X	X		X	X	X	X	X	X
<div> <div> C - Classroom  MC - Mediated Classroom  LC - Learning Center  PTT - Part Task Trainer  CFT - Cockpit Familiarization Trainer </div> <div> CPT - Cockpit Procedures Trainers  IFT - Instrument Flight Trainer  FS - Flight Simulators  WST - Weapon System Trainer  A/C - Aircraft </div> </div>										

2. FS. Flight simulators are later generation devices than the IFT. They represent more advanced simulation technology in all areas of flight simulation and are typically more plentiful in commercial than in military applications. They are also typically digital rather than analog devices.
3. WST. Weapon System Trainers represent the most advanced state-of-the-art of the three categories. Their advantages over FSs lie largely in visual and radar simulation improvements and in capabilities to link other crew positions with the flight station for full-crew-coordination training. They may also be linked to other simulators or WSTs for inter-flight-crew-training and tactics training. Air Force is currently procuring a limited number of these devices.

Consideration of these training devices does not imply that each school has all three. WSTs, for example, are currently being procured for only the B-52 and KC-135. Advanced state-of-the-art simulators are more plentiful in commercial aviation than in the military; however, Air Force simulator procurement is proceeding at an increased rate. For a comprehensive reference of current simulator utilization in flight training, see (1) T.A.E.G. report 43, "Current Simulation Substitution Practices in Flight Training," February 1972, and (2) Armed Services Committee, 93rd Congress, "Flight Simulators." 13 May 1976.

Table 1-5 shows the subset of functions/tasks common to SAC and MAC and the level of proficiency to which each was judged trainable in each of the three types of current simulators just discussed. The common functions/tasks are shown vertically on the table and the three simulators across the top. Numeric entries within each cell of the resulting matrix represent proficiency levels obtainable in each of the simulator types. For those functions showing no corresponding task breakdown, proficiency levels are estimated for the function as a whole.

In reading table 1-4, it is cautioned that the proficiency level estimates (cell values) are generally representative of 5 separate aircraft types. Variations among the individual aircraft missions and flight profiles are significant, as are procedural requirements of the respective aircrews. Therefore, while proficiency levels shown are generally accurate, their interpretation for a specific aircraft type might not be warranted.

**2.3.2.3 Resources/Trainability Estimates.** To this point the common subset of training tasks has been presented, training resource requirements have been identified, and estimates of the extent to which the common tasks can be trained on current simulators have been provided. In the identification of training resource requirements, definitions were provided for the complete range of training resources typically implemented by the Air Force. Since these definitions are available, it was decided to estimate the extent of training which can be provided on each of the defined resources rather than stop with currently available simulators. These estimates are shown in table 1-6. As in table 1-5, extent of training provided is shown as proficiency level obtainable for each resource listed.

TABLE 1-5. PROFICIENCY LEVELS OF TRAINING TASKS AS A FUNCTION OF SIMULATOR TYPE

	IFT	FS	WST
Cruise			
Autopilot Usage	N/A*	3	4
Weather Avoid	N/A	1	4
Global Procedures	N/A	4	4
ADIZ Proc's	N/A	4	4
O <sub>2</sub> Usage	N/A	4	4
Asymmetric Thrust			
Takeoff	2	4	4
Trail	2	3	4
Approaches	2	4	4
Missed Approaches	2	4	4
Landings	N/A	4	4
Crew Coord.	2	2	4
Check List			
Use, Pace &			
Procedures	2	3	4
<p>* N/A means the simulator is not typically equipped to provide this type of training.</p> <p>IFT - Instrument Flight Trainer  FS - Flight Simulator  WST - Weapon System Trainer</p>			

TABLE 1-6. PROFICIENCY LEVELS OF TRAINING TASKS AS A FUNCTION OF TRAINING RESOURCES

	*	LC	PTT	CFT	CPT	IFT	FS	WST
Cruise								
A/P Usage	1	1	3	2	3	N/A	4	4
Wx Avoid	1	1	N/A	N/A	N/A	N/A	1	4
Global Proc's	3	3	N/A	N/A	4	N/A	4	4
ADIZ Proc's	3	3	N/A	N/A	4	N/A	4	4
O <sub>2</sub> Usage	2	2	4	3	4	N/A	4	4
Asymm. Thrust								
Takeoff	1	1	2	N/A	2	2	4	4
Trail	1	1	N/A	N/A	N/A	2	3	4
Approaches	1	1	2	N/A	2	2	4	4
Missed App's	1	1	2	N/A	2	2	4	4
Landings	1	1	N/A	N/A	N/A	N/A	4	4
Crew Coord.	1	1		2	2	2	2	4
List Use,								
Pace & Proc's	1	1		2	2	2	3	4
NOTE: For convenient reference the previous chart is repeated in the last 3 columns of this one.								
* This column includes classroom (C) and mediated classroom (MC)								
N/A means the training device is not typically equipped to provide this type of training.								

Neither of the tables presented in this subsection provides estimates of trainability for the projected TTB training aircraft for SUPT. There are two reasons for this omission. First, any of the functions/tasks can be trained to proficiency level 4 in the aircraft given the appropriate enabling knowledge and skills and enough practice time. Second, the skill level of most concern is not high proficiency in the SUPT training aircraft, but rather, an entry-level proficiency appropriate to the operational aircraft to which the student is assigned. For example, the student might obtain level 4 on asymmetric thrust takeoff in the SUPT trainer, yet only rate a 3 or less in the C-141 or B-52. For these reasons, estimates of the extent of training provided by the identified resources have been oriented toward the long-term operational needs rather than the short term SUPT.

In addition, it is important to remember that the information compiled and presented here was in answer to the question of whether, and to what extent, the tasks can be trained in current military and commercial flight simulators. In the data collection visits to the training bases, the instructors and staff were queried as to the availability of equipment which might be used in the projected UPT TTB track. The only current equipment of the type mentioned in this report (PTT, CFT, IFT, etc.) so identified, were two T-40 instrument trainers. These T-40 trainers could be used beneficially in UPT for the training of asymmetric thrust, and are presumably available. The CTS training staff said that all other training equipment is being used in the CTSs and is not available for use in UPT. CTS training personnel were queried on this point for the sole purpose of estimating the availability/existence of general categories of training devices. The query itself is strictly hypothetical in that ATC has no intention of trying to acquire any of the training devices from the CTSs for use in UPT. That such training devices may be procured for UPT, however, is an important option for future planning.

In summary, this section provides information about a wide range of training resources and the training capabilities they provide. This information could be used in cost/benefit studies of different strategies for allocating training resources.

## CHAPTER 3

### CRITERIA AND BENEFITS

#### 3.1 OVERVIEW

How much will MAC and SAC benefit from TTB pilot lead-in training? The answer is a function of several factors which includes the exact composition of the set of tasks in which training is given and the commonality of these tasks. Logicon has collected and analyzed data on task commonality as well as data on criticality and other factors. Finally, Logicon has developed a methodology for estimating benefits and applied a simplified version of that method to the data. The results indicate that SUPT would give UPT pilots better preparation for their first flights in SAC and MAC, and the training benefits could, within limits, be converted into different forms at the option of the Air Force.

##### 3.1.1 Task Selection Criteria

SUPT will encompass a finite number of tasks to be taught. Therefore the best possible SUPT will have to include the best selection and combination of training tasks. The criterion for task selection, then, raises the question of task benefit to the UPT graduate and the Air Force. If the question can be answered, the most effective set of tasks can be chosen for any given cost or other set of constraints.

The next logical question is: How can benefits be measured or predicted? That question is examined in detail below.

##### 3.1.2 Basic Model for Benefits

Training benefits come from somewhere - from some tasks being taught in some way - and they are used in some way; e.g., to improve the product of the training, or to reduce costs, or some combination of these and other outcomes. A model of benefits can be built upon these basic facts.

#### 3.2 SOURCES OF BENEFITS

In the specific area of UPT for TTB pilots and copilots, the benefits of interest here stem from the choices of tasks to be trained. The benefits of training each task can be expressed as a function of key factors and terms. These include:

1. The commonality of the task between SAC and MAC
2. The frequency and duration of the task
3. The criticality of the task to the success and safety of the mission
4. The generalizability of the task.

### 3.3 THE USES OF BENEFITS

In this contract, Logicon is not responsible for recommending or predicting the way a training benefit should be used. However, Logicon emphasizes the fact that a training benefit can, within limits, be converted into different forms according to the desire of the user. To illustrate, suppose training efficiency is increased by a certain factor. That factor could be applied in several ways: (1) to increase the number of nice-to-know topics in the curriculum, (2) to raise the level of student proficiency in need-to-know topics, (3) to increase the number of students put through the school, (4f.f.) etc., etc., But it could not be applied in all ways. Someone would have to make the choice of what to buy with the improved training efficiency.

In other words, a benefit is to some extent a negotiable quantity.

It should also be noted that we are now dealing only with the training benefits side of the ledger. Costs, for items such as fuel and simulator time, can also be analyzed; and they may be raised or lowered (as indicated in previous Air Force operations analyses) as a result of training practices. The detailed analysis of such cost changes would be an entirely different project.

### 3.4 METHODS OF ESTIMATING BENEFITS

During the course of the contract, Logicon devised and tested a Full Formula Method of estimating benefits. A simplified version of this formula was used in interim work. Earlier still, a survey method of estimating benefits was used. These methods are described below, in chronological order of use.

#### 3.4.1 Survey Method

The first-used method of estimating benefits from SUPT was to use instructor questionnaires and interviews (the forms for which are reproduced in an appendix to this report) to identify the present student's areas of weakness, and also to ask how SUPT would remedy these weaknesses.

This survey method was used for two reasons. First, it was simple and direct. Second, it was expected to be compatible with the basic method, which was finally developed. This, in turn, was meant to be a mathematical version of the common-sense factors which the instructors presumably used in estimating benefits.

#### 3.4.2 Simple Formula Method

In interim work, prior to developing a generalizability method, Logicon used the following formula:

$$\text{Benefits} = \frac{\text{TTB-irrelevant hours}}{\text{Total UPT hours}}$$

The full formula, described below, may be considered an elaboration of this simple formula. In particular, a generalizability term is included in the

full formula. Also, critically and frequency, treated explicitly in the full formula, are approximated here by the relative time now given in UPT to training the different tasks. Furthermore, commonality is considered here as a binary variable; that is, a task is considered either relevant or irrelevant to TTB training, with no in-between degrees of relevancy or commonality. In the full formula, in-between degrees are considered.

### 3.4.3 Full Formula Method

This method is based on the factors and terms listed in the description of the basic model. Some of them are defined below.

Let  $T$  = any task which may be trained in TTB pilot lead-in training.  
Let  $B_T$  = the benefits of training task  $T$   
Let  $C_T$  = the commonality of task  $T$   
Let  $F_T$  = the frequency and duration of task  $T$   
Let  $S_T$  = the criticality of task  $T$

Before combining these symbols in a formula, note that overall exposure to danger in a task is a product of its frequency and duration. In other words,  $S_T$  and  $F_T$  are multiplicative. Note also that this would be true for one command even if the task were completely irrelevant to the other command.

If commonality is low, a task may nevertheless be very important. But if the task is completely common to MAC and SAC, then one may consider it to be about twice as important. In other words, commonality as a factor is zero if the task is needed for neither MAC nor SAC, one if it is needed for only one command, one and a fraction if used partly by both, and two if used identically by both MAC and SAC.

The observations of the above paragraphs can be summarized symbolically as:

$$B_T = S_T F_T C_T$$

That is the basic Logicon formula for estimating the benefits of TTB pilot lead-in training. It provides a procedure for comparing the benefits of training or not training different tasks. And, if any set of tasks is suggested for TTB lead-in training, the formula can be used to give a figure-of-merit for comparing that suggested set with any other set.

Readers will immediately recognize that the formula has limitations as well as capabilities for expansion. The prime limitation is that the scaling of  $S$ ,  $F$ , and  $C$  may not be realistic, with the result that  $B$  may be a non-linear measure of benefits. In the jargon of measurement theory,  $B$  may be only an ordinal scale, and not an equal-interval or ratio scale.

Also, the formula implies that  $S$ ,  $F$ , and  $C$  have equal weight or importance. But one may want to assign different weights to them. Of course this could

be done if the weights (designated s, f, and c) could be agreed upon. Then the formula would become:

$$B_T = S_T^s F_T^f C_T^c$$

If a task has generalizability, the learning it entails is applicable to a variety of situations and aircraft. This generalizability adds to, or supplements commonality; it makes the results of training in a task more valuable to both MAC and SAC. Thus, generalizability could be added to the formula. Designating generalizability as G, and using a constant K to indicate the relative importance of generalizability versus commonality, the full formula would then become:

$$B_T = S_T^s F_T^f (C_T + KG_T)^c$$

### 3.5 DATA COLLECTION

The basic data collection procedures were described in previous chapters of this report. Data were provided by the answers, given by SAC and MAC training personnel, to questions about what UPT graduates need to know.

Additional data were provided by SAC and MAC training manuals which listed the tasks to be taught.

Finally, information was needed on such task attributes as frequency, duration, and criticality. Estimates of data in these areas came from the manuals, the questionnaires and interviews, and from the recent military experience of personnel at Logicon.

### 3.6 RESULTS

#### 3.6.1 Survey Method Results

Anecdotal evidence was collected from the AF C-130 school at Little Rock AFB, which has actually been teaching students with both generalized UPT and SUPT backgrounds, and has had a chance to compare their performance. (The generalized UPT graduates are from the Air Force, whereas the Navy UPT graduates who go to C-130 school have been through specialized training in multi-engine propeller aircraft.) The four instructors who were interviewed said the Navy student pilots are better prepared initially for asymmetric thrust procedures, checklist pacing, crew coordination, performance, and other activities which concern multi-engine operation in general.

The SAC and MAC interviews, which were much more extensive, produced comparable results. When asked to list the student's weak areas and the training that causes the recent UPT graduate the most trouble, instructors reported crew coordination, asymmetrical thrust and lack of rudder usage in general, checklist usage and pacing, conventional box traffic patterns and communications. Landings were also listed, with the major problems caused by the different landing pitch attitudes between T-38 and the CCTS aircraft.

KC-135 personnel listed weak instrument proficiency with the major problem area being slow/incomplete crosscheck. The cause appears to be the students' initial flight director background and then later exposure to the KC-135 FD-109 system for the first time at the CCTS. The C-141 and C-130 training supervisors and instructors listed low altitude approach procedures as an area that could be improved. These low approaches, like the KC-135 FD 109 system problem, are not common since SAC aircraft do not fly the low altitude structure.) Judgment and decision making (described in the 1978 Field Evaluation Report as a "Continuing Criticism") do not seem to be large problems to the recent UPT graduate in SAC and MAC CCTSs. This is probably due to the fact that decisions are made by the aircraft commanders.

Clearly, SUPT/dual track could remedy some of these problems. Others, like the FD-109 system problems on the KC-135, might be ignored on the basis of their uniqueness. In fact, the equipment on a state-of-the-art trainer aircraft of the mid-1980s will require considerable difference training in order to transition to the obsolescent operational aircraft.

Based on conclusions drawn from the instructor and student questionnaires, interviews and information gathered from the ATC UPT (Field) Evaluation Reports of 1975 and 1978, estimates of training benefits may be derived in these areas by SUPT, and are reasonable to pursue on the basis of their commonality.

Students will be more knowledgeable in multi-engine operations and in their ability to overcome asymmetric thrust problems. A particularly beneficial aspect of the dynamic observer (teaching technique by which one trainee observes the training situation and the actions of another) program is that during the early phases of training the second student can handle the communications and then, as he/she becomes more proficient in flying the aircraft, more knowledgeable of procedures and more experienced in radio operation, he/she can accomplish all three. (The CCTSs have used this method for years.) Thus, the TTB graduate will be much better prepared in all phases of communications.

Realistically, in the T-38 the pilot cannot refer to the checklist during all situations or all phases of flight. In the TTB trainer aircraft it will be possible and realistic to use the checklist in the manner that SAC and MAC desires. Therefore, checklist usage and pacing will be another task in which the entering student will be better prepared.

The TTB trainer aircraft will fly a standard multi-engine traffic pattern and will undoubtedly have a landing attitude and other characteristics closer to the larger MAC and SAC operational aircraft than does the T-38. Consequently, the student will be better prepared in landings and VFR patterns.

Since the TTB trainer will have a minimum crew of two, there must be some coordination between the two crew members. The TTB graduate will thus have a basic understanding of crew coordination.

In the three-position TTB trainer the third person can act as a safety observer. Low level navigation and air drop fundamentals training should be much improved. (Note: this is not a common task.)

If the proposed TTB trainer had some equipment not currently projected, the UPT graduate could be better prepared in other areas. Suggested equipment might include another UHF and an HF radio, an autopilot, weather avoidance and/or ground mapping radar, an inertial navigation system, etc.

### 3.6.2 Simple Formula Results

The simple formula was applied to three phases of T-38 training. These were classroom instruction, simulator missions and flight. For each phase, a benefit ratio was calculated. This is the ratio of the projected training hours which could be replaced with TTB-specific training in a dual track program. Thus the larger the value of the benefit rating the more benefit there would be in replacing hours considered to be irrelevant with TTB-specific hours.

According to the June 1978 Syllabus of Instruction for UPT, 62.4 hours of classroom time are devoted to the average student. Of this total, an estimated 19.5 hours are judged to be irrelevant to TTB requirements. (Examples of subjects deemed irrelevant are ground training units and prebriefs in advanced contact maneuvers and the major parts of basic, advanced, night and three and four ship formation procedures.) Thus, the benefit ratio which could theoretically be obtained for classroom instruction is:

$$\frac{19.5}{62.4} = .31$$

For simulator training the ratio is:

$$\frac{1.3}{68.9} = .02; \text{ since only 1.3 of the 68.9 hours were judged to be irrelevant.}$$

Flight training was broken into three categories to distinguish among types of training provided in the aircraft. The first category was described in the syllabus as basic instrument and contact sorties. The second was formation flying, and the third was navigation. The initial phase included 37.2 hours, of which 11.0 were deemed irrelevant or questionable for the TTB pilot. The benefit ratio calculated for this phase is:

$$\frac{11.0}{37.2} = .30$$

Formation flying included 44.0 hours of which 14.0 were estimated to be irrelevant. The estimate for this phase is:

$$\frac{14.0}{44.0} = .32$$

Of the 17.0 hours in the navigation phase, all were judged to be contributory to its training. Thus, the benefit ratio is 0.

Overall, for the flying phase, of the total of 98.2 hours, 25.0 hours in the present syllabus could be omitted, for an overall benefit ratio for flying of:

$$\frac{25.0}{98.2} = .25$$

The above percentages can be reduced to a single, more meaningful figure by weighting them according to the proportionate number of hours currently devoted to the UPT phase in which the training task occurs; that is, academics, simulators and flight. These weights are:

- 0.27 for academics tasks (based on 62.4 hours of academics)
- 0.30 for simulator tasks (based on 68.9 hours)
- 0.43 for flight training tasks (based on 37.2 hours)
- (Total : 168.5 hours)

The following arithmetic results:

- For academics  $(.31)(.27) = .084$
- For simulator phase  $(.02)(.30) = .006$
- For flight phase  $(.25)(.43) = .108$
- Weighted average benefit ratio = .198

Thus, when training phases are weighted according to their criticality, the greatest benefit is predicted for the flight phase of UPT, the next greatest for academics, and next, the simulator phase.

For completeness, the three segments of the flight phase are weighted with the following results:

- For instrument/contact  $(.30)(37.2/98.2) = .114$
- For formation flying  $(.32)(44/98.2) = .143$
- For navigation  $(.00)(17/98.2) = 0$
- Weighted average benefit ratio (flight) = .257

### 3.6.3 Full Formula Results

During the course of the contract, Logicon made extensive use of the simpler methods of predicting benefits. However, the full formula could not be used until the generalizability method was refined. Since the work on generalizability was one of the last tasks in the contract, time permitted the full formula method to be exercised on only a small sample of possible TTB training tasks. The results of this exercise are given below.

First it was necessary to assign constants to the formula. These constants are weighting factors for the factors and terms in the formula. Their assignment began with an examination of the estimated ranges and averages of the components of the formula. These estimated data are given in table 1-7.

TABLE 1-7. ESTIMATED AVERAGES AND RANGES FOR  
COMPONENTS OF BENEFITS EQUATION

	C = Commonality between SAC & MAC	F = Frequency of Task	S = Success Safety Criticality	G = General- izability
Estimated Average	.5	2	2	.5
Expected Range	0 - 1	1 - 3	1 - 5	.2 - 1.

The commonality range and average in the table came from the work described in this section's chapters 1 and 2. The frequency and criticality scales came from standard Air Force scales and procedures. The generalizability estimates grew out of the work described in Appendix C.

As a first tuning of the formula, it was decided to give equal weight to the terms for commonality and generalizability. In other words,  $(C + KG)$  became  $(C + G)$ . It was also decided to give equal weight to each of the three factors. In other words,  $S^S F^F (C+G)^C$  became simply  $SF(C+G)$ . Leaving off the subscripts indicating a particular task, the formula for benefits became:

$$B = SF(C+G)$$

Applying this formula to the numbers in table 1-7 gives the following results:

Estimated Average  $B = 4$ .  
Expected Range of  $B = 0.2$  to  $30$ .

To repeat a note of caution given earlier in this chapter,  $B$  represents an ordinal scale, which can be used to rank training tasks in order of merit, but which probably should not be used, prior to further tuning, for statistics assuming an equal-interval or ratio scale of measurement. The distribution of  $B$  could be statistically normalized to approximate an equal-interval scale. However, Logicon did not perform such normalization because it would add another layer of mathematics on the benefit method and it might seem to move the method farther from the actual data.

Appendix C, Chapter 3 described the derivation of the generalizability ( $G$ ) estimates used below. The frequency ( $F$ ) and criticality ( $S$ ) estimates came from subject-matter experts at Logicon.

The tasks on which the full formula was exercised were (1) asymmetric thrust procedures, and (2) landing.

Results (rounded to two significant figures) are given in table 1-8. (Remember that Benefit refers to training in SUPT as opposed to later training of the task in the field.)

TABLE 1-8. FULL FORMULA APPLIED TO TWO TASKS

<u>Task</u>	<u>S</u>	<u>F</u>	<u>(C</u> + <u>G)</u>	=	<u>Benefit</u>
Asymmetric Thrust	5	1	.8	1	9.
Landing	5	2	1	.49	15.

By calculating G for selected tasks for all combinations of aircraft, it would be possible to predict the extent to which training of a task on an aircraft would generalize to any other. A format for the display of the results is given in table 1-9. To summarize the difficulty of transitioning for any one aircraft to another, mean G's for a set of tasks could be calculated and displayed similarly.

TABLE 1-9. FORMAT FOR DISPLAY OF INTER-AIRCRAFT GENERALIZABILITY

<u>TASK : ASYMETRIC THRUST</u>							
	KC-135	C-130	C-141	B-52	C-9	C-5A	TTB AC
KC-135	1.0						
C-130		1.0					
C-141			1.0				
B-52				1.0			
C-9					1.0		
C-5A						1.0	
TTB AC							1.0

Use of the full benefits formula, as illustrated in table 1-8, permits examination of its components as well as its results by subject matter experts and training specialists. The exercise indicates that the resulting benefit figures do provide a method of ordering the merit of possible tasks for training in SUPT for TTB. Therefore, further use of the full formula is strongly recommended.

### 3.7 CONSERVATION BENEFITS

In addition to the kinds of benefits discussed above, the possibility also exists that benefits could be converted into conservation of such resources as instructor flight and/or simulator time. On the basis of Logicon's analysis of the results, as well as the interviews with Air Force personnel, the consensus of opinion at this time includes the following: (1) A TTB dual track UPT with the 22 training tasks taught to SAC and MAC standards would contribute to a reduction in CCTS flying time. (In the case of C-5A, this flying time costs about \$5000 per hour.) (2) No reduction of flying hours could be made at the beginning flying level in UPT. (3) The addition of realistic trainers (WSTs) in the CCTSs and the TTB track graduates' better preparation would permit SAC and MAC to achieve their projected reduction of

flying training hours. (4) Instructor hours in UPT may, if anything, increase. Instructor workload in the CCTSs could perhaps be lowered; but the TTB commands may not realize the reduction in the long run, because MAC and SAC will be funneling instructor personnel into ATC. During a specialized UPT, instructors would be better prepared with operational backgrounds. The TTB flight Simulator will be new to the inventory so they will not have a training time per student until the education and training requirements have been established. However, as long as one goal of the training program is to ensure the graduating trainee can successfully handle the possible situation he/she might encounter, and because flight simulators are safer and more effective than the airplane since the actual hazards can be avoided, (5) simulator time will not be reduced. In cost comparisons between flight simulators and aircraft, the flight simulators have proved to be less costly in terms of both purchase and operating cost. This factor, as well as the increasing acceptance of the environmental and psychological fidelity in simulators, and the high effectiveness of training, also indicate that flight simulators will be utilized to the maximum.

The benefit to be received is that of being able to set higher standards for the students, resulting in a more experienced and proficient graduate — a better entering product for the CCTSs. This, in turn, should result in cost and time savings in his initial CCTS phases. At the same time, advantages to entry-level students often tend to diminish as training progresses. At some point, entry-level advantages may disappear altogether, as a result of being overshadowed by the experience factor.

## SECTION 2

### CANDIDATE TTB PERFORMANCE MEASUREMENT SYSTEM (PMS) METHODOLOGY

This section describes a methodology for use in the performance measurement of the individual TTB aircrews and is comprised of 4 chapters. Chapter 1 discusses the concept, environment and scope, and parameters in TTB particular performance measurement. Chapter 2 presents recommendations of methods to be used in a TTB performance measurement system. Training tasks suitable for performance measurement are listed and the recommended measurement method is identified. Chapter 3 gives examples of specifications for implementing such recommendations.

## CHAPTER 1

### TTB PERFORMANCE MEASUREMENT CONSIDERATIONS

The approach of this chapter is to cite the general concepts of performance measurement and apply them to TTB training.

#### 1.1 PURPOSE

Performance measurement in the context of an entire training program such as TTB training will have a wide variety of purposes. Measurement of entry level proficiency to determine baseline capability may be the initial purpose. Other purposes of performance measurement would be to determine the trainee's progress through each phase and to document the attainment of proficiency in the myriad training tasks and behavioral objectives addressed in the program. In the final phases of training, the purpose of performance measurement would be to determine the extent to which trainees are capable of performing operational missions.

#### 1.2 ENVIRONMENT

The measurement environments within the TTB training program will cover a broad spectrum depending upon the material to be assessed. Academic learning and cognitive performance would be measured in a classroom or learning center environment. Checklist procedures, such as normal and emergency checklist performance, and various crew coordination tasks could be measured in the cockpit procedures trainer environment. Certain flight procedures and crew interactions would be assessable in a simulated flight environment, whereas measurement of operational performance could be accomplished only in the aircraft.

#### 1.3 SCOPE

For each performance measurement situation the scope of measurement must be determined. In some instances very little data are needed to determine adequately the trainee's level of performance; in other situations a great deal of data are required. In the academic setting, one or two test items dealing with a particular learning objective may suffice. At the other end of the spectrum, in the realm of the multicrew flight environment, a great variety of pilot and copilot activities would be measured and each activity would be frequently sampled. The scope of measurement, for each activity under consideration in the TTB training program, must be carefully established in order to collect enough data to ensure adequate assessment without collecting superfluous or redundant information.

#### 1.4 VARIABLES

The specific variables to be measured represent the behaviors which are the focus of training. These behaviors range from listing items in the course of a paper-and-pencil test to controlling the aircraft itself. Typically the performance measurement variables are keyed to the terminal behavioral

objectives of each phase of a training program. However, where these behavioral objectives are non-existent, a determination of the behavior or performance which is the end result of the training must be made. Similarly the situational factors surrounding each performance variable as well as the standards of performance must be established for each variable.

#### 1.5 SCORING

The collection of performance data may be accomplished in a variety of ways. These include paper and pencil tests, instructor observation, automatic measurement by computer, and semi-automatic measurement. The determination of which method of data collection is used depends on the measurement situation and the data available. In some cases the performance data collection may be completely automated. In other situations the measurement of performance is manually accomplished, and in others a large degree of automatic measurement is augmented through manual input.

Manual input of performance measurement data on the part of an instructor or instructional specialist must not be confused with subjective input. Ideally, all aircrew performance measurement data must be objective in nature (i.e., observable or verifiable). The data collection issue, therefore, is not whether the performance measure is objective or subjective, but whether the objective measurement is made manually or automatically. Automatic measurement may take place any time a machine is capable of assessing performance. This may take the form of answer sheet scoring, interactive computerized teaching consoles, or simulator and on-board computer data collection and processing. Manual measurement is accomplished by a person trained to determine the extent to which the standards of student performance are met and to record the level of proficiency attained. A combination of manual and automatic performance measurement is certainly attainable, and in some instances the combination is a preferable alternative to an exclusive method of measurement.

The assignment of scores to performance measurements can be one of the most complex aspects of the assessment situation due to the wide variety of grading requirements possible. A scoring algorithm may be required which provides a global grade of proficiency for the entire training program. The algorithm would include separate grades for the various segments of training (academic, simulator, flight), or scores for each phase of training within the segments. In any case, the performance variables addressed in the training course must be separately assigned scores and must be individually weighted for inclusion in the appropriate algorithm to accurately reflect their importance in accomplishing the training mission.

## CHAPTER 2

### RECOMMENDATIONS

#### 2.1 DEGREES OF AUTOMATION

In a flight simulator training environment, performance measurement may be accomplished in several ways. First, assessment may be made automatically within the simulator's computational equipment or through the application of peripheral computer equipment. This may be referred to as machine measurement. Secondly, assessment is made by the simulator instructor or other instructional personnel qualified to assess the degree by which performance standards are met. While the measurement of performance in this case is done by an evaluator, the manual measurement is entered into the computational system for inclusion into the total measurement and scoring algorithm. Manual evaluation is accomplished with reference to established, objective standards of student performance. A human evaluator makes the performance assessment on the basis of objective tolerances and standards as stated in the training objectives of the flight training syllabus. Subjective human judgments, therefore, are not a factor in flight crew performance measurement as all behaviors to be demonstrated by the student pilot are of a quantitative and observable nature. The third method of measurement involves a combination of machine and manual assessment and entails the virtually simultaneous collection of manual performance measurement input along with machine measurement. Examples of the uses of these three types of performance measurement methods are included in the following listing.

1. Machine: Checklist activities - the simulator's computational system notes the sequence and accuracy of the pilot's activities in completing various checklists.

Flight parameters - the computational system measures discrepancies in aircraft flight parameters such as airspeed, altitude, heading, etc.

2. Manual: Any activity which is not measurable by the simulator's computational system but which is to be included in the mission measurement and scoring algorithm (i.e., personal equipment, mission planning, knowledge of regulations, etc.).
3. Combination: Interactive checklists during which specific switch actions as well as voice communications are to be accomplished. In these cases, the computational system measures switch actions and the evaluator measures and inputs the accomplishment of verbal responses.

The human input to the simulator's computational system may be accomplished via a wide range of input devices including keyboard and touch panel.

#### 2.2 RECOMMENDED DEGREES

In the following list, specific training tasks are identified as being machine measurable (1), manually measurable (2) or measurable through a combination of machine and manual input (3).

1. Ground Operations
  - a. Personal Equipment (2)
  - b. Maintenance and Operations Forms (2)
  - c. Preflight Exterior Inspection (2)
  - d. Preflight Interior Inspection (1)
  - e. Postflight Interior Inspection (1)
  - f. Postflight Exterior Inspection (2)
  - g. Mission Planning (2)
  - h. Regulations (2)
  - i. Aircraft Limitations (1)
2. Pre-Takeoff/Post-Landing
  - a. Engine Start - Cartridge (3)
  - b. Engine Start - Pneumatic (3)
3. Takeoff - Day and Night
  - a. Static (1)
  - b. Rolling (1)
  - c. Water Augmented (1)
  - d. Crosswind Crab (1)
  - e. Maximum Effort/Obstacle Clearance (1)
  - f. MITO (1)
4. Climb/Level Off
  - a. Instrument Departure (3)
5. Basic Control
  - a. Airbrake Usage (1)
  - b. Trim Usage (1)
  - c. Flap Usage (3)

- d. Slat Usage (3)
- e. Gear Usage (3)
- f. Flight Controls (1)
- 6. Instruments/Precision Control
  - a. Control Instruments (1)
  - b. Performance Instruments (1)
  - c. Navigation Instruments (1)
  - d. Instrument Cross-check (3)
  - e. Instrument Cross-check Analysis (2)
  - f. Navigation Procedures (1)  
(As described in AFM 51-37, Chapter 2, Section E)
  - g. Steep Turns (1)
  - h. Vertical "S" (1)
- 7. Normal Flight Departure and Recovery
  - a. Initial Buffet/Stall Recognition (Pwr on/off, Flaps up/dn) (1)
  - b. High Sink Maneuver (1)
  - c. Slow Flight (1)
  - d. Unusual Attitudes (Simulator) (1)
- 8. Radio Nav Aid Navigation
  - a. Jet Route Navigation (1)
  - b. TACAN Fix-to-Fix Navigation (1)
  - c. Victor Airways Navigation (1)
- 9. Cruise
  - a. Autopilot Usage (1)
  - b. Radar Weather Avoidance (1)
  - c. Global Procedures (3)

- d. ADIZ Procedures (3)
- e. Oxygen Usage (1)
- 10. Visual/Air-Based Radar Navigation - Day and Night
  - a. Pilotage/DR (1)
  - b. Radar Ground Mapping (1)
  - c. Terrain Avoidance Radar (1)
  - d. Electro-optical Viewing System (1)
  - e. Entry and Exit (3)
- 11. Air Drop Fundamentals - Day and Night
  - a. Pilotage/DR (1)
  - b. Instruments (BDI/TG) (1)
- 12. Cell Formation - Day and Night
  - a. Departure and Join-up (1)
  - b. Enroute (1)
  - c. Position Changes (3)
  - d. Rendezvous (3)
- 13. Trail Formation - Day and Night
  - a. Lead (1)
  - b. Receiver (1)
  - c. Breakaways (3)
- 14. Communications
  - a. Interphone (3)
  - b. UHF Operation (3)
  - c. HF Operation (3)
  - d. VHF Operation (3)
  - e. Intra-plane (3)

- f. Ground/Tower (3)
- g. Enroute (3)
- h. Tactical (3)
- i. Departure/Approach (3)
- 15. Emergency Procedures
  - a. Flags Up Approach and Landing (3)
  - b. Emergency Descent (3)
  - c. Anti hijacking (3)
  - d. Slats Only Landing (3)
  - e. Crash Landing/Ditching (3)
- 16. Asymmetrical Thrust - Day and Night
  - a. Takeoff (3)
  - b. Trail Formation (3)
  - c. Approaches (3)
  - d. Missed Approaches (3)
  - e. Landings (3)
- 17. Crew Coordination (3)
- 18. Checklist Usage, Pacing and Procedures (3)
- 19. Decision Making
  - a. Judgment (3)
  - b. Directive Compliance (3)
- 20. Collision Avoidance
  - a. Visual (3)
  - b. Collision Avoidance System (3)
- 21. Holding/Descent/Approach
  - a. Holding Pattern (High) (3)
  - b. Holding Pattern (Low) (3)

- c. Enroute Descent (3)
- d. Published Penetrations (3)
- e. VFR Traffic Pattern (3)
- f. PAR Approach (3)
- g. ILS Approach (3)
- h. ASR Approach (3)
- i. TACAN Approach (3)
- j. VOR Approach (3)
- k. ADF Approach (3)
- l. VOR/DME (3)
- m. Localizer (3)
- n. Back Course Localizer (3)
- o. Circling Approach (3)
- p. Coupled ILS Approach (3)
- q. VOR Procedures (3)
- r. TACAN Procedures (3)
- s. ILS Procedures (3)
- t. ADF Procedures (3)
- 22. Landing - Day and Night
  - a. Full Stop (3)
  - b. Touch and Go (3)
  - c. Crosswind (3)
  - d. Short Field Operations (3)
  - e. Drag Chute Operation (3)

## CHAPTER 3

### EXAMPLES OF IMPLEMENTATION SPECIFICATIONS

Variables for monitoring and general modes of measurement were recommended in the previous chapter. The implementation of these preliminary specifications for a TTB PMS must now be discussed. Examples of these specifications are provided in this chapter. (The examples were selected and edited from a report involving a logically related effort: "System Specification for Performance Measurement for C-5A Simulator," prepared by Logicon under contract F 33615-78-C-0027 for the USAF. See also AFHRL-TR-78-54: "Definition of Requirements for a Performance Measurement System for C-5 Aircrew Members," by J. Swink, E. Butler, H. Lankford, R. Miller, H. Watkins, and W. Waag, AFHRL/FTD, Williams AFB, Oct. 78).

The specifications are described in terms of (1) the definition of the mission profile (which affects the system), (2) the definition of performance monitoring, (3) the assessment of proficiency in monitored tasks, and (4) the display and feedback capabilities which should be provided.

#### 3.1 MISSION PROFILE DEFINITION

The mission profile must be defined in sufficient detail so that it can be used by the real-time PMS software as a basis for monitoring, measuring and assessing performance. The following paragraphs describe the definition and formatting instructions for a C-5A mission profile.

##### 3.1.1. Navigation Profile Definition

In addition to checklists and procedures, navigational profiles shall be a part of the mission scenario definition.

A navigational profile shall be a flight structure for which the PMS monitors the aircraft adherence to a predefined geographical track, and to prescribed altitude limits. For each navigational profile, there shall be a displayable background track. Navigational profiles shall include the following flight structures:

1. Instrument Departures
2. Enroute Structures
3. Holding Patterns
4. Initial Approaches/Non-precision Final Approaches
5. Precision Final Approaches.

### 3.1.2 Format Instructions

The mission shall be specified for one of several combinations of crew members (pilot, copilot, flight engineer). Each session shall consist of a set-up block of data and a series of logical mission phases. The set-up blocks of the mission profile definition require aircraft configuration, TOLD card, departure and monitorable parameter information. Subsequent to these blocks are the mission phase data block.

The scenario for a mission shall be logically divided into phases. Each phase of a mission shall be organized around one normal checklist. It is within a mission phase that malfunctions shall be entered, and various procedures, other checklists, and navigational profiles shall be specified to be monitored. The following paragraph exemplifies the scope of navigational profiles.

The instrument departure shall be defined from the point at which the aircraft takes off, to the termination point of the instrument departure. The navigational legs of the instrument departure shall be defined in terms of ground navigational aids. Only the terminal point of the instrument departure profile may be an Inertial Navigation System (INS) waypoint. The instrument departure definition shall not allow for radar vectoring. This is because the PMS has no speech interface with the crew, and so could not measure planned versus actual aircraft navigation via radar vectoring.

The enroute navigational profile shall be defined in terms of ground navigational aids and/or INS way points. Normally, the start point of the enroute leg would be the terminal point of the instrument departure. The terminal point of the enroute leg typically would be an entry to a holding pattern or else an initial approach. The holding pattern shall be defined with respect to any TACAN, VOR, or NDB for which certain data are available. The data required for a navigational aid shall be its identification, type of station, frequency/channel, latitude, longitude, elevation, and the magnetic variation at the station. This includes TACAN, VOR-DME, ILS-DME, VOR, ILS, NDB, LOC, and LOC BC approaches. The initial approach definition includes a nonprecision final approach. As with instrument departures, radar vectoring shall not be included in the type of monitoring PMS can support. Both GCA and ILS precision final approaches may also be defined and used in a mission with or without an initial approach.

The final data block for a mission profile definition contains the assessment scoring parameters which shall be used in arriving at the various assessment level scores for a mission.

The mission profile structure allowed by the PMS shall give the mission writer considerable flexibility to specify the actions/performance PMS will monitor and when PMS will monitor them. The same flexibility exists for specifying when PMS will enter/remove various malfunctions. Because of this flexibility, the mission writer should define the mission such that mission progress and performance monitoring may proceed in an automatic fashion. This will enable the mission to be run in an automated mode, ensuring standardization and validity of performance measures. It also negates instructor

requirements for manual (keyboard) inputs and ensures timeliness of the entry. This reduces the instructor's workload and frees him/her to concentrate upon student performance. Finally, reliability of performance measurement is enhanced by omitting the possibility of manual entry errors and ensuring repeatability.

### 3.2 PERFORMANCE MONITORING DEFINITION

The PMS shall dynamically monitor crew performance with respect to the following categories: checklists/procedures, navigational profiles, aircraft parameters. The following paragraphs will cover how each category shall be monitored.

#### 3.2.1 Checklists and Procedures

When PMS is used in aircrew training, it shall monitor the accomplishment of all normal and emergency checklists and procedures which have been specified in the requested mission. Since procedures and checklists shall be monitored in the same way, the term procedure is used in this section to subsume that of checklist unless otherwise indicated. At times checklist itself refers specifically to the proper checklists defined in appropriate Technical Orders.

The normal and emergency checklists and, more generally, the normal and emergency procedures defined in aircraft Technical Orders are expressed as lists of steps, conditions, notes, and descriptions of crew performance and aircraft responses. For purposes of objective monitoring, these procedures must be reduced to sequences and series of readily verifiable checks and states.

#### 3.2.2 Navigational Profiles

The real-time monitoring of navigational profiles shall be done in parallel with the monitoring of checklists/procedures and parameters. The only navigational profiles that will be monitored during the course of a mission shall be those that are predefined in the mission scenario.

The following list shows the categories of monitorable navigational profiles.

1. Instrument Departure
2. Enroute
3. Holding Pattern
4. Initial Approach and Non-Precision Final
5. Precision Final Approach: GCA
6. Precision Final Approach: ILS

### 3.2.3 Aircraft Parameters

A parameter shall be defined as any item whose value is monitored within certain defined limits. These limits may change from one portion of the mission to another. Each set of limits shall be called an envelope for the parameter. The following sections discuss the conditions by which the PMS real-time software shall initiate or terminate the monitoring of a parameter envelope, as well as how the envelope monitoring shall be done.

3.2.3.1 Envelope Initiation and Deactivation. Each envelope shall have a default start condition so that the value for the parameter may be monitored per the limits set down by the envelope. These default start conditions are actuation conditions which, when true, shall cause the PMS real-time software to begin monitoring the parameter per the active envelope.

Because a parameter will be able to have several envelopes, the envelope initiation software shall begin with the first envelope in the list to see if its default start condition has been satisfied. If it has, the software activates that envelope and proceeds with the next parameter. At any one time, only one envelope per parameter shall be monitored. If a parameter already has an active envelope, the PMS software shall not check the default start conditions for any other envelopes for that parameter. Because of the sequential check of the envelopes of a parameter to determine if one will be monitorable, the closer an envelope is in the sequence to the top, the more likely it will be initiated ahead of another envelope if both of their default start conditions should be satisfied at the same time.

However, an envelope which is further down in the sequence, but active, shall prevent any other envelope from becoming active for that parameter. An envelope shall automatically be deactivated whenever its default stop condition becomes true. Default stop conditions for envelopes shall exist in several forms. If an envelope is defined to be active for a period of time, it shall be deactivated when that time elapses. Similarly, if an envelope is defined to be active until an actuation condition becomes true, it shall be deactivated when that condition becomes true. Likewise, if an envelope is defined to be active while a monitorable condition is true, it shall be deactivated when that condition is no longer true.

The manual mode control commands of terminate, score, and suspend for parameters shall also serve to deactivate an envelope. When monitoring for a parameter is started or continued, the default start conditions for the envelopes shall be used for activating the appropriate envelope.

3.2.3.2 Envelope Monitoring. The assessment that will be associated with some parameter envelopes shall be for the crew member, pilot or copilot, who is actually flying the aircraft at the time each sample was obtained. The ASSESS FLYER option in the envelope definition shall provide the means by which the appropriate envelopes may be identified. During parameter data sampling, the basis for determining which crew member is flying the aircraft shall be a function of which yoke or control column was last moved (based upon availability of simulator data).

The display of parameter data at each instructor station display shall contain only information relevant to the envelopes which are active.

### 3.3 PROFICIENCY ASSESSMENT DEFINITION

The preprogrammed scenario shall contain performance monitorable tasks. A task shall consist of individual performance measures which together are intended to be reflective of the proficiency required for accomplishing the task. The flexibility available in defining these tasks shall lend itself to including significant performance measures in the tasks, to the extent that data are available from the simulator.

#### 3.3.1 Categories of Monitorable Tasks

There shall be three categories of performance monitorable tasks. The checklist/procedure tasks shall consist primarily of actions that are to be performed at discrete times. The basic unit of proficiency assessment shall be the step of the checklist/procedure. Another category of performance monitorable task shall be the parameter, for which a parameter value shall be monitored over a period of time. The basic unit of proficiency assessment shall be the parameter envelope. The difference between a step and an envelope is that a step shall be measured at some point in time, whereas an envelope shall be measured over a period of time. Placing the landing gear down versus monitoring that the gear is down on final approach is an example of step versus envelope.

The final category of a performance monitorable task shall be the navigational profile. Its performance measures shall relate solely to maintenance of a specified track and altitude and shall consist of both single and continuous sample measures.

Proficiency assessment scores shall be defined for each basic unit of performance measure in the mission scenario. Each performance measure may apply to one or more individual crew members, and may contribute to an overall crew coordination proficiency assessment. Therefore, several proficiency assessment scores may be assigned to an individual performance measure; each score being assigned to particular crew member/crew coordination category for the performance measure.

The algorithms for combining these individual performance measures scores, and an overview for all of the various levels of proficiency assessment are discussed in the ensuing paragraphs.

#### 3.3.2 Overview of Levels of Assessment

There shall be five levels of proficiency assessment for a mission exercise. Table 2-1 summarizes these levels of assessment.

Just as the definition of the individual performance monitorable tasks shall include level 1 and 2 assessment criteria data, the mission profile overview definition must include assessment criteria data for levels 3 through 5. These data shall be used in the algorithms described in the following paragraphs.

TABLE 2-1. OVERVIEW OF LEVELS OF ASSESSMENT

Level: 1

Title: Performance Monitorable Task Assessment

Description: Combination of individual step/performance measure/envelope scores into a single score for the performance monitorable task (checklist/procedure, navigational profile, parameter). There will be a separate score for each crew member/crew coordination associated with the task.

Level: 2

Title: Performance Monitorable Task Group Assessment

Description: Combination of scores for all performance monitorable tasks belonging to the same group; e.g., a checklist-procedure score for all checklists/procedures that the copilot participated in or was accountable for. There will be a separate score for each session.

Level: 3

Title: Crew Member/Crew Coordination Assessment

Description: Combination of the summary performance monitorable task scores from level 2, for a crew member or for crew coordination; e.g., the pilot's score in session 1 reflecting the proficiency assessment for his/her performance in all applicable checklists, procedures, navigational profiles, and parameters.

Level: 4

Title: Session Assessment

Description: Combination of the pilot, copilot, flight engineer, and crew coordination proficiency assessment scores into a single score

TABLE 2-1. OVERVIEW OF LEVELS OF ASSESSMENT (Continued)

for the session.

Level: 5

Title: Mission Assessment

Description: Combination of the proficiency assessment scores for both sessions.

Each step of a checklist/procedure shall be individually monitored during a mission exercise. Each step shall have associated with it a possible point value. Figure 2-1 presents a level 1 assessment for the pilot for a sample checklist.

Data for all applicable performance measures for a navigational profile shall be collected during a mission exercise. The performance measures shall consist of both discrete and continuous value measures. In the example in figure 2-2 performance measure 1 is a discrete measure that was correctly accomplished. The remaining performance measures each have defined acceptable tolerances.

Parameter data samples shall be collected for each monitorable envelope during a mission exercise. This data shall be used to arrive at a data error for each envelope. There shall be three types of data errors, each type corresponding to an assessment criteria defined for that envelope, as shown in figure 2-3. Envelope 2 will be assessed on the basis of the parameter's RMS deviation (3) being not greater than the defined acceptable tolerance (4). Envelope 3 will be assessed on the basis of the parameter's value being wrong (at most 4%) for all occurrences for the applicability of the envelope. Envelope 6 will be assessed on the basis that the parameter's value be out of limits for less than 1 second. Each envelope will receive full possible points when the data error is less than or equal to the data limit (envelopes 1, 2, 3, and 7). When the data error exceeds the data limit, the envelope will receive earned points equal to (possible points) x (data limit/data error).

A summary assessment will be computed for all training task groups for each crew member and for the parallel crew coordination assessment. Figure 2-4 contains a sample set of checklist/procedure score data for C-5A pilot 6831. The algorithm for combining this data will be identical to the algorithm for levels 3, 4, and 5 assessment.

In the example, the first three columns of data reflect the results of a level 1 assessment of checklists and procedures. They could be data from various parameters or from various navigational profiles. The last three columns reflect assessment criteria data that will be defined for each training task.

The crew member assessment shall also include summary crew coordination performance assessment. Figure 2-5 presents an example of level 3 assessments for each party in session 1 of a mission exercise. Note that there shall be no navigational profile assessment for flight engineers. The same algorithm described for level 2 assessment shall apply to level 3 assessment. Note that the weight column in the example in figure 2-5 provides a weighting to the training task group scores. This shall enable the mission builder to arrive at an empirically-derived meaningful interpretation for the higher-level scores for all exercises of the same mission scenario.

The session assessment algorithms (level 4) shall combine the crew member and crew coordination scores as shown in figure 2-6.

# SAMPLE LEVEL 1 ASSESSMENT FEEDBACK

CHECKLIST/PROCEDURE:				
CREW	ENGINE SHUTDOWN			
P: 6831	EARNED	POSS	LEVEL	
STEP & CONSTRAINTS	POINTS	POINTS	FACTOR	VIOLATION
STEP 1 BRAKE SWITCH 'EMER'	7	7	0.95	
STEP 2 PARKING BRAKE 'SET' CONSTRAINT: NR 4 HYDRL PRESS	3	6	0.68*	SEQ
STEP 3 INST PWR SW 'EMER' CONSTRAINT: NR 2 HYDRL PRESS CONSTRAINT: EMER PWR LT ON	8	8	0.70	
STEP 4 CONT IGNIT 'OFF' CONSTRAINT; FUEL BOOS OFF	0	10	0.67	CON
STEP 5 FUEL/STRT IGNITION 'OFF' CONSTRAINT; THROTTLES TO IDLE CONSTRAINT: 5 MIN ENG IDLE CONSTRAINT: EXTERNAL PUR AVAIL	10	10	0.35	
STEP 6 NAV & ANTI-COL 'FLASH/OFF'	0	4	1.00*	OMT
STEP 7 WINDSHIELD HEAT 'OFF'	5	5	1.00	
PRELIMINARY EARNED POINTS			33	
LEVEL FACTOR			0.45*	
EARNED POINTS			15	
POSSIBLE POINTS			50	
PERCENTAGE			30	

Figure 2-1. Example of Checklist/Procedure Level 1 Assessment

# SAMPLE LEVEL 1 ASSESSMENT FEEDBACK

CREW: P-6831

NAVIGATIONAL PROFILE: ABQ HOLDING PATTERN

PERFORMANCE MEASURE	EARNED POINTS	POSSIBLE POINTS	DATA ERROR	TOLERANCE LIMIT	LEVEL FACT
1	5	5	CORRECT		1.00
2	5	5	1	1	1.00
3	0	10	0.5	0.2	0.90*
4	10	10	1.2	1.5	0.95
5	10	10	35	50	0.95

PRELIMINARY EARNED POINTS	30
LEVEL FACTOR	0.90*
EARNED POINTS	27
POSSIBLE POINTS	40
PERCENTAGE	68

Figure 2-2. Example of Navigational Profile Level 1 Assessment

# SAMPLE LEVEL 1 ASSESSMENT FEEDBACK

CREW: P-6832

PARAMETER: XYZ

PARAM ENV	EARNED POINTS	POSS PTS	DATA ERROR	DATA LIMIT	LIMIT TYPE	ACHVD %	MIN %	LEVEL FACT
1	10	10	2	2	A	100	90	1
2	15	15	3	4	A	100	80	.9
3	25	25	2	4	B	100	100	.3
4	21	28	4	3	A	75	75	0
5	20	25	5	4	A	80	85	.5*
6	0	20	1	0	C	0	100	.8*
7	20	20	0	0	A	100	99	.7

KEY TO DATA LIMIT TYPES  
 A: TOLERANCE/RMS DEVIATION  
 B: % MISSED OCCURRENCES  
 C: MAX TIME OUT OF TOLERANCE

PRELIMINARY EARNED POINTS 111  
 LEVEL FACTOR 0.4\*  
 EARNED POINTS 44  
 POSSIBLE POINTS 143  
 PERCENTAGE 33

Figure 2-3. Example of Parameter Level 1 Assessment

# SAMPLE LEVEL 2 ASSESSMENT FEEDBACK

CREW

P: 6831

SESSION: 1

## CHECKLIST/PROCEDURES

	EARNED PTS	POSSIBLE PTS	PERCENTAGE	MINIMUM PERCENT	LEVEL FACTOR	WEIGHT
PILOT						
CHECKLIST/PROCEDURES	370	740	50	70	0.90	1.50
BEFORE STARTING ENGINES	20	25	80	90	1.00*	1.00
APU FIRE - IN PLACE	10	20	50	50	0.90	2.00
STARTING ENGINES	25	40	62	50	0.90	1.00
HOT START	30	30	100	70	0.95	1.00
BEFORE TAXI	30	40	75	85	1.00*	0.50
TAXI	12	12	100	85	1.00	1.00
BEFORE TAKEOFF	18	18	100	85	1.00	1.00
LINEUP	10	10	100	85	1.00	1.00
TAKEOFF REJECT	3	12	25	55	0.72*	3.33
AFTER TAKEOFF/CLIMB	15	20	75	80	1.00*	1.00
INFLIGHT ENG SHUTDOWN	45	50	90	60	0.60	2.00
AIR START	25	30	83	60	0.60	2.00
LOSS OF OIL QTY	15	20	75	60	0.90	2.00
DESCENT	30	30	100	85	1.00	1.00
APPROACH	20	20	100	85	1.00	1.00
BEFORE LANDING	40	40	100	85	1.00	1.00
RESET-RESYNC SLATS	20	25	80	70	0.90	2.00
AFTER LANDING	30	40	75	75	1.00	1.00
LOSS OF FLUIDS CHECK	30	30	100	70	0.85	1.00
ENGINE SHUTDOWN	15	50	30	60	0.90*	1.00
BEFORE LEAVING PLANE	20	25	80	80	0.90	1.00

PRELIMINARY EARNED POINTS	570
LEVEL FACTOR	0.65*
EARNED POINTS	370
POSSIBLE POINTS	740
PERCENTAGE	50

Figure 2-4. Example of Level 2 Assessment

# SAMPLE LEVEL 3 ASSESSMENT FEEDBACK

## CREW MEMBER AND COORDINATION SCORES

SESSION: 1  
P: 6831  
CP: 4273  
FE: 6852

	EARNED PTS	POSSIBLE PTS	PERCENTAGE	MINIMUM PERCENT	LEVEL FACTOR	WEIGHT
PILOT	1800	3000	60	60	0.90	1.00
CHECKLIST/PROCEDURES	370	740	50	70	0.90*	2.00
PARAMETERS	130	160	81	80	0.80	5.00
NAVIGATIONAL PROFILES	305	360	85	80	0.70	2.00
COPILOT	1620	2000	81	70	0.95	1.00
CHECKLIST/PROCEDURES	600	800	75	70	0.90	1.50
PARAMETERS	160	200	80	70	0.80	2.00
NAVIGATIONAL PROFILES	100	100	100	80	0.70	4.00
FLIGHT ENGINEER	600	600	100	96	0.85	3.00
CHECKLIST/PROCEDURES	400	400	100	95	0.80	1.00
PARAMETERS	200	200	100	95	0.70	1.00
CREW COORDINATION	650	750	87	50	1.00	2.00
CHECKLIST/PROCEDURES	350	400	88	70	1.00	1.00
PARAMETERS	100	150	67	50	1.00	1.00
NAVIGATIONAL PROFILES	200	200	100	70	1.00	1.00

Figure 2-5. Example of Level 3 Assessment

SAMPLE LEVEL 4 AND LEVEL 5 ASSESSMENT FEEDBACK

MISSION AND SESSION SCORES

	EARNED POINTS	POSSIBLE POINTS	PERCENTAGE	MINIMUM PERCENT	LEVEL FACTOR	WEIGHT	LEVEL 5 SCORE	LEVEL 4 SCORE
MISSION SCORE	14070	17250	82					
SESSION 1	6520	8300	79	50	1.00	1.00		
PILOT	1800	3000	60	60	0.90	1.00		
COPILOT	1620	2000	81	70	0.95	1.00		
FLIGHT ENGINEER	600	600	100	96	0.85	3.00		
CREW COORDINATION	650	750	87	50	1.00	2.00		
SESSION 2	7550	8950	84	50	1.00	1.00		
PILOT	2450	2900	84	60	0.90	1.00		
COPILOT	1800	2200	82	70	0.90	1.00		
FLIGHT ENGINEER	700	750	93	96	0.80	3.00		
CREW COORDINATION	600	800	75	50	0.90	2.00		
CREW	SESSION 1		SESSION 2					
PILOT	6831	4273						
COPILOT	4273	6831						
FLIGHT ENGINEER	6852	3475						

Figure 2-6. Example of Level 4 and Level 5 Assessment

The mission assessment algorithm (level 5) shall combine the scores for each session. Figure 2-6 presents an example of a mission score that is derived from two session scores.

### 3.4 PERFORMANCE DISPLAY AND FEEDBACK CAPABILITY

The PMS shall provide the following display and feedback capabilities:

1. Mission Sequence Display: summary displays of the sequences of tasks
2. Mission Plot Display: graphic presentation of aircraft progress with reference to ground track
3. Route Chart Display: graphic background displays corresponding to departure, enroute, and approach plates
4. Checklist/Procedure Display: displays of pre-defined sequences of actions to be performed by crew members
5. Error Alert Display: message alerting instructor to crew errors as they occur in the pre-defined tasks
6. Proficiency Assessment Display: detailed alphanumeric displays relative to any specific pre-defined performance segment or task
7. Debriefing Report: hard-copy, objective performance data upon which the instructor may assess and evaluate performance.

#### 3.4.1 Categories of Displays and Feedback

The categories of displays and feedback shall be:

1. Mission Sequence and Status Displays
2. Checklist/Procedure Displays
3. Navigational Profile Displays
4. Parameter Displays
5. Error Alert Displays
6. Special Function Displays
7. Debriefing Report

The format for the display of information on each instructor display shall be the same. The top line of the display shall be reserved for messages generated in response to instructor keyboard entries and for error alert messages. The remaining lines of the display shall be allocated for all of the other types of information presentations. The following paragraphs present detailed information regarding each of these types of displays.

3.4.1.1 Mission Sequence and Status Displays. There shall be three types of mission sequence and status displays. All three shall be available at each instructor display. The first is the mission sequence display illustrated in figure 2-7. This display shall present the summary status for each training task defined in the entire mission scenario. The alphanumeric names for the tasks shall be obtained from the MONITOR statements in the mission scenario overview definition. Associated with each training task listed (checklists, procedures, and navigational profiles) shall be a 2-digit training task identifier that shall be used in the access of detailed performance information for that training task. The time into the mission at which the training task is started shall be noted; likewise the completion time. If the training task is terminated or suspended, that information shall also be placed on the display as shown in figure 2-7.

A second type of display shall be the malfunction block status display which is illustrated in figure 2-8. The alphanumeric text for each malfunction block shall be obtained from the mission overview definition. With each block shall be a 2-digit identifier that will be useful to the instructor in referencing that malfunction block when the PMS is operating in the manual mode.

3.4.1.2 Checklist/Procedure Display. This display shall identify the status of each predefined step in the checklist/procedure. Only the checklist/procedure step information applicable to the instructor station's crew member(s) shall be presented at the instructor's station. Figure 2-9 presents a sample checklist display.

3.4.1.3 Navigational Profile Display. These displays shall only be accessible at the IP station. They shall consist of a background anticipated route profile, an overlaid aircraft track history of greater intensity, and an alphanumeric display of current aircraft altitude, heading, and airspeed. Displays for all profiles except precision final approaches shall present horizontal ground tracks (no graphic altitude information) with locations of essential vertical obstacles (e.g., mountain peaks) clearly marked. Figure 2-10 presents a sample instrument departure display. The precision final approach displays shall consist of final approach course and glideslope graphic displays. Figure 2-11 presents a sample ILS approach display.

3.4.1.4 Parameter Display. The display of monitorable status shall consist of detailed information regarding the parameter's value and the applicable envelope restrictions. The only parameters that shall be displayed at an instructor station will be the ones with envelopes that are predefined for his/her crew member(s).

Figure 2-12 illustrates a sample parameter display. The parameter 2-digit identification shall be listed in the left column of the display. The status column shall reflect which parameters have values that are currently out of limits. It shall also reflect whether the instructor has terminated or temporarily suspended monitoring for the parameter.

ERROR ALERT:

MISSION SEQUENCE

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SESSION 1

START STOP

C	1	BEFORE INTERIOR .....	0:00:00	0:15:00
C	2	INTERIOR .....	0:15:30	TERM
C	3	BEFORE STARTING ENGINES .....	0:30:00	0:35:00
P	4	INS SET UP .....	0:35:00	0:40:00
P	5	ALTERNATE FUEL MANAGEMENT.....	0:35:00	
C	6	STARTING ENGINES .....	0:40:10	0:45:00
P	7	LOW OIL PRESS 2 .....	0:40:50	0:42:00
P	8	BEFORE TAXI .....	0:46:00	SUSP
P	9	GROUND CROSSWIND RESET .....	0:52:00	0:58:00
C	10	PTU 1-2 CMPT FIRE .....	0:53:00	
C	11	TAXI .....		
C	12	BEFORE TAKEOFF .....		
P	13	BUS TIE OPEN LT 1 .....		
C	14	LINEUP .....		
P	15	MAKEOFF THROTTLE SETTING .....		
P	16	MANUAL PRESSURIZATION .....		
P	17	CROSSWIND RESET IN FLT .....		
C	18	IN FLT ENGINE 1 SHUTDOWN .....		

Figure 2-7. Sample Mission Sequence Display

ERROR ALERT:

MALFUNCTION BLOCK STATUS

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SESSION 1

STATUS

1 BLOCK

COMPLETED

WHEN INTERIOR CHECKLIST COMPLETED:

SET 25 LITER OXYGEN TO SLOW,  
SET 75 LITER OXYGEN TO SLOW.

2 BLOCK

TERMINATED

WHEN OXYGEN LOW WARNING LIGHT COMES ON,  
AFTER 120 SECONDS:

SET 25 LITER OXYGEN TO NORM,  
SET 75 LITER OXYGEN TO NORM.

3 BLOCK

ACTIVE

WHEN ENGINE 2 START BUTTON IS IN:  
SET OIL PRESSURE VARIATION TO -10.

4 BLOCK

WHEN RECIRCULATING FAN SWITCH IS ON  
ENTER MALFUNCTION 910

Figure 2-8. Sample Malfunction Block Status Display

ERROR ALERT:

STARTING ENGINES PROCEDURE

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START COND: ASSESSMENT OF BEFORE STARTING ENGINES

STOP COND: MONITOR BUS SWITCH 2 - NORMAL

STOP COND: AND MONITOR BUS SWITCH 3 - NORMAL

START TIME: 2:15:30

	STATUS	SEQ	SUSP TIME
AIR COND MASTER SWITCH - OFF	SEQ	3	0:25
BEGIN NSQ			
ATM #1 PUMP - OFF		2	0:16
ATM #2 PUMP - OFF		1	0:10
SYS 1-2 PTJ BOOST PUMP - OFF		4	1:07
SYS 3-4 PTU BOOST PUMP - OFF	OMT		
END			
ENGINE INSTRUMENTS - NORMAL	N/A		
BEGIN NSQ			
IF ENGINE #1 HUNG START THEN			
AUG AIR SWITCH #1 - OFF	CON	5	2:15
IF ENGINE #2 HUNG START THEN			
AUG AIR SWITCH #2 - OFF			
IF ENGINE #3 HUNG START THEN			
AUG AIR SW #3 - OFF			

Figure 2-9. Sample Checklist Display

NAVIGATIONAL PROFILE  
INSTRUMENT DEPARTURE: CDS 2-CDS  
ALTITUDE 9000 HEADING 270 AIRSPEED 250

ERROR ALERT:

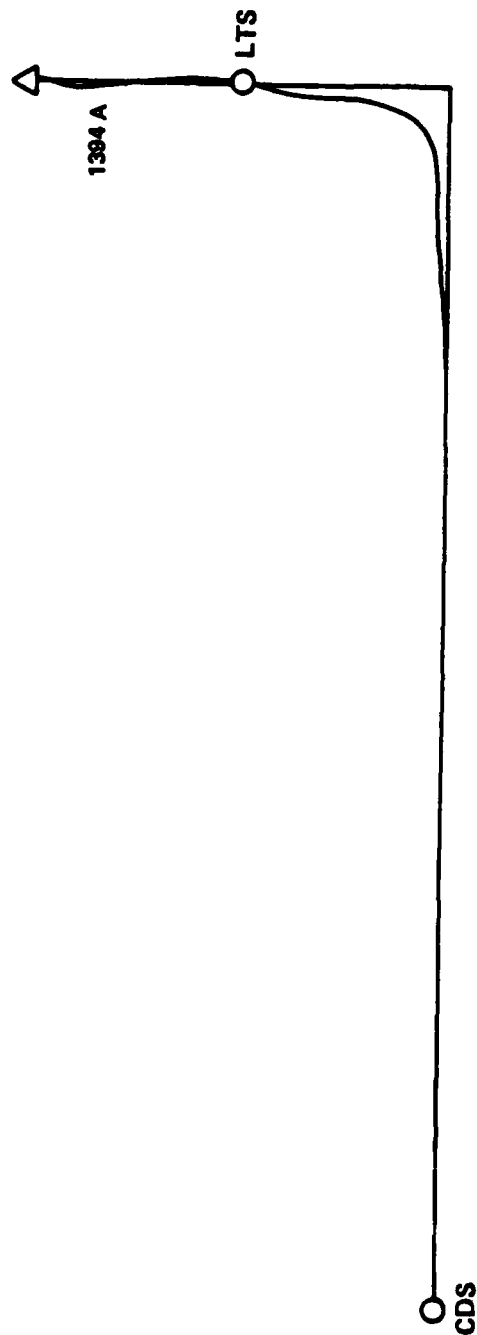


Figure 2-10. Sample Instrument Departure Display

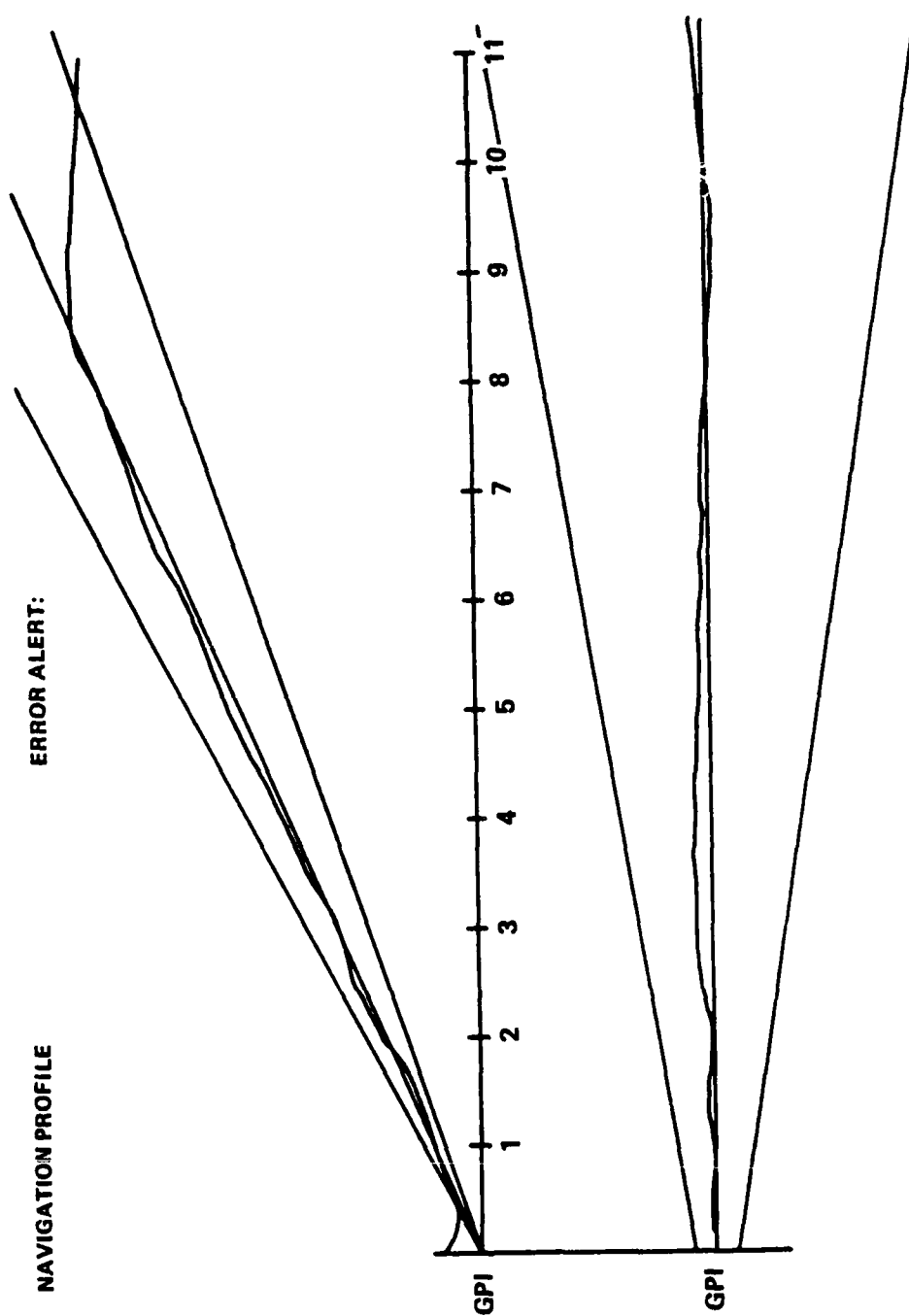


Figure 2-11. Sample ILS Approach Display

ERROR ALERT:

PARAMETER STATUS

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	PARAMETER	STAT	CURRENT VALUE	LOWER LIMIT	NORM	UPPER LIMIT	ENV NO
1	AIRSPPEED		300	290	300	310	4
2	MACH		.77	.75	.76	.77	2
3	BANK ANGLE		-1	-10	0	10	2
4	PITCH		0	-5	0	5	2
5	G LOADING	SUSP					
6	AOA	TERM					
7	VERTICAL VELOCITY	TERM					
8	HEADING	OUT	350	355	360	005	2
9	YAW	SUSP					
10	ENGINE 1 N1		80	17		106	1
11	ENGINE 2 N1		81	17		106	1
12	ENGINE 3 N1		80	17		106	1
13	ENGINE 4 N1		79	17		106	1
14	ENGINE 1 N2		80	61		100	3
15	ENGINE 2 N2		80	61		100	3
16	ENGINE 3 N2		80	61		100	3
17	ENGINE 4 N2		80	61		100	3

Figure 2-12. Sample Parameter Display

3.4.1.5 Error Alert Display. A portion of the top line of each display shall be reserved for error alert messages. The alert message shall notify the instructor of crew errors in real time. This shall enhance the instructor's ability to provide real-time performance feedback to the crew member. It shall also enhance the real-time diagnosis capabilities for the instructor.

The alert message shall be repeated at some convenient interval until the instructor acknowledges it at his/her keyboard. The alert shall include the training task identification that the instructor will have to use in referencing the display appropriate to the training task in which the error was made. For example:

"ERROR ALERT #15: CHECKLIST 23"

3.4.1.6 Special Function Displays. There shall be three types of special function displays available at each instructor station. The first shall be a keyboard response message on a portion of the top line. It shall note whether the entry just made was acceptable or in error.

The second type of display shall be the "help" display. This shall consist of tutorial information regarding the use of the PMS keyboard and the access of displays.

The third type of display shall identify the current values of particular data items that may be changed at the instructor keyboard.

3.4.1.7 Debriefing Report. The debriefing report shall be generated at the conclusion of the mission exercise. Table 2-2 contains a list of the types of information it shall document. This shall include all computed proficiency assessment information for each level of assessment. Level 1 assessment printouts shall include detailed information regarding each performance measure defined for the training task. The score data for all assessments at all levels shall be accessible for post-mission analysis.

The malfunction status report shall include malfunction processing operations performed in the mission. This record shall enable evaluators of the mission exercise to correlate errors in performance with malfunction status in the aircraft.

TABLE 2-2. DIVISIONS OF THE DEBRIEFING REPORT

- |  |
|--|
| a. Level 4 and 5 assessments                                 |
| b. Level 3 assessments                                       |
| c. Level 2 assessments                                       |
| d. Level 1 assessments plus other performance measure detail |
| e. Malfunction status  |
| f. Parameter envelope details by mission segment             |

A list of all envelopes applicable to each mission segment in each session shall be generated. This shall enable evaluators of the mission exercise to synthesize the overall status of the aircraft during various phases of the mission.

#### 3.4.2 Display Selection at Instructor Station

The displays appropriate to each instructor station shall be accessible via the instructor keyboard. Table 2-3 contains a list of the types of displays that shall be accessible. Many of the displays listed shall consist of multiple pages of information. Whenever a new display is selected, the first page of the information shall be presented. The successive pages shall be accessible by means of a page-advance function key at each keyboard.

TABLE 2-3. INSTRUCTOR DISPLAY SELECTIONS

Mission Sequence Display
Malfunction Block Status Display
Active Malfunction Display
Checklist/Procedure Display
Navigational Profile Display
Parameter Display
Error Alert Display
Keyboard Response Display
Help Display
Changeable Data Display

Only the displays appropriate for the current session shall be available for display. Displays for checklists/procedures that remain to be initiated shall also be displayable. Displays for checklists/procedures that have been completed for over approximately ten minutes shall no longer be available for access. Displays for navigational profiles that are not active shall not be displayable.

## APPENDIX A

### INSTRUCTOR QUESTIONNAIRE

The following appendix provides copies of each of the instructor, staff and pilot questionnaires which were administered in Phase I of this study. Pilot questionnaires included Academic Pilot and Pilot. The former was administered to recently-entered student pilots who were just completing the academics phase of CCTS; the latter to student pilots completing the flight phase. The appendix also includes a copy of the guidelines used in the interviews and discussions with instructors and staff. It is entitled Interview Checklist.

### INSTRUCTOR QUESTIONNAIRE

This questionnaire has been developed to assist in the identification of training requirements for ATC. The questionnaire was designed for both SAC and MAC IPs, so if something looks strange to you, it is for the other guy. The information will be used in the development of a Tanker/ Transport/- Bomber (TTB) pilot course as a part of UPT. Please take your time and answer the questions thoroughly and conscientiously. Answer only the questions relating to instructional duties you have performed at this base. If a question does not apply to your job or aircraft, please write N/A. Thank you very much for your time and suggestions.

Base \_\_\_\_\_ Aircraft you instruct in \_\_\_\_\_

Name (optional) \_\_\_\_\_ Rank \_\_\_\_\_

Present duty: Academic Inst. \_\_\_\_\_ Flight Line Inst. \_\_\_\_\_ Simulator Inst. \_\_\_\_\_

Previous duty  
at this base: Academic Inst. \_\_\_\_\_ Flight Line Inst. \_\_\_\_\_ Simulator Inst. \_\_\_\_\_ None \_\_\_\_\_

Today's date \_\_\_\_\_

Number of months you have been an instructor at this base \_\_\_\_\_

Please circle the number below which best describes how UPT graduates are prepared for your school.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

1. Listed below are some training areas in which UPT students may encounter difficulty. If you have found that an area is a very difficult one for the students, put V beside it. If it is moderately difficult, put M beside it. If it just causes some difficulty, put S beside it. If it causes no difficulty, leave the item blank. If it is not in your training syllabus, put N/A beside it.

\_\_\_\_ Mission Planning  
\_\_\_\_ Crew Briefings  
\_\_\_\_ Aircraft Systems  
\_\_\_\_ Communications - Making required calls, hearing all interphone  
and radio transmissions and responding  
\_\_\_\_ Decision Making  
\_\_\_\_ Crew Coordination  
\_\_\_\_ Checklist usage and pacing  
\_\_\_\_ Knowledge of Instrument procedures  
\_\_\_\_ Maintaining proper azimuth on another aircraft  
\_\_\_\_ Maintaining proper elevation on another aircraft  
\_\_\_\_ Being able to close on another aircraft  
\_\_\_\_ Normal procedures  
\_\_\_\_ Emergency procedures  
\_\_\_\_ Instrument flying  
\_\_\_\_ Navigation  
\_\_\_\_ Takeoffs  
\_\_\_\_ Landings  
\_\_\_\_ VMC traffic transition flying

2. List any other areas in which students encounter difficulties. Rate them V, M, or S, as you did in question 1.

3. Which of these difficult areas (rated V, M, or S in questions 1 and 2) is not taught at UPT?

4. From the list below, please select (by circling the numbers) the items a student must do or know to qualify in the aircraft in which you instruct.

1. Use performance data charts
2. Complete flight planning forms
3. Make rolling takeoffs
4. Make water takeoffs
5. Make formation takeoffs
6. Make minimum interval takeoffs (MITO)
7. Make cell departure and join ups
8. Do unusual attitude recoveries in the simulator
9. Do unusual attitude recoveries in the aircraft
10. Do high altitude navigation
11. Use ground-based nav aids
12. Use celestial procedures in coordination with navigator
13. Use grid procedures in coordination with navigator
14. Use airborne radar (pilot radar ground map navigation and weather navigation)
15. Use dead reckoning procedures
16. Do low level navigation by visual means
17. Fly low level with terrain avoidance radar
18. Perform systems crosscheck and station check
19. Know bombing procedures
20. Know cargo drop procedures
21. Know global procedures
22. Fly published holding patterns
23. Fly published high altitude penetrations
24. Fly LORAN approaches
25. Fly airborne radar directed approaches
26. Know VOR procedures
27. Know TACAN procedures
28. Know ILS procedures
29. Know GCA procedures
30. Fly LOW ALTITUDE Instrument Approaches
31. Know ADF Procedures
32. Know VFR procedures
33. Know LOW ALTITUDE instrument procedures
34. Perform air refueling as a receiver
35. Perform air refueling as a tanker

5. List all tasks not included above which are performed in your aircraft and taught to your students.

6. In what areas are the entering UPT students best prepared?

Please list what you think the reasons are for their being better prepared in these areas.

7. How would you change the present UPT training program?

In what areas and how would this benefit training?

FOR THE FOLLOWING QUESTIONS, ASSUME PUT HAS MULTI-ENGINE AIRCRAFT (NON-CENTERLINE THRUST) AND TRAINING DEVICES.

8. a. Where would you teach checklist usage and pacing? Check one or both of the following

UPT

Advanced Training

- b. How would you teach checklist usage and pacing?

Academics (if this is your choice, check one or more of the following instructional methods or media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

(PTT) Part task trainers

(CFT) Cockpit familiarization trainers

(CPT) Cockpit procedures trainers

Other (please explain)

Simulators

Aircraft

- c. Where and how are they now taught?

9. a. Where would you teach radio/interphone communications? Check one or both.

UPT

Advanced Training

- b. How would you teach communications?

Academics (if this is your choice, check one or more of the following instructional methods or media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

- c. Where and how is it now taught?

10. a. Where would you teach asymmetrical thrust flying and associated skills? Check one or both.

UPT

Advanced Training

- b. How would you teach these areas?

Academics (if this is your choice, check one or more of the following instructional methods or media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

- c. Where and how is this now taught?

11. Based on your experience, what are the factors which bring about good crew coordination?

12. a. Where would you teach crew coordination? Check one or both of the following:

UPT

Advanced Training

b. How would you teach crew coordination?

Academic (if this is your choice, check one or more of the following instructional methods and media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

c. Where and how is it now taught?

13. a. Assuming you could have a multi-engine aircraft (non-centerline thrust), motion simulators and any other training devices you wanted, how would you change UPT?

b. Why?

14. Please state your opinions about dual track training (vs. generalized pilot training).

STAFF QUESTIONNAIRE

NAME \_\_\_\_\_ RANK \_\_\_\_\_ DATE \_\_\_\_\_  
BASE \_\_\_\_\_ POSITION \_\_\_\_\_

(You will not be quoted on any of these questions.)

1. Please circle the number below which best describes how UPT graduates are prepared for your school.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

2. Based on your studies, in what UPT training areas are recent graduates weak?

3. Of the training you give here (which is not taught at UPT), what causes the recent UPT graduate the most trouble?

Why?

AD-A088 730

LOGICON INC SAN DIEGO CALIF

F/G 5/9

SPECIALIZED UNDERGRADUATE PILOT TRAINING: TANKER/TRANSPORT/BOMB--ETC(U)

AUG 80 J DEAN, R OVERTON, R MILLER

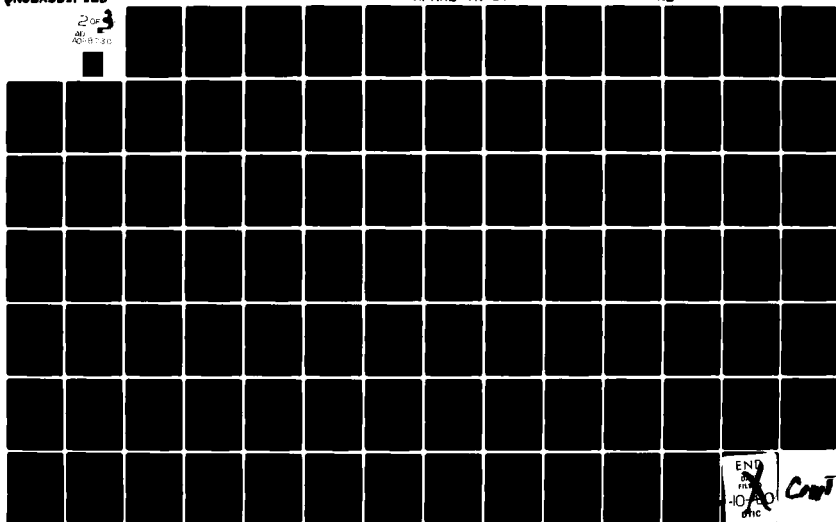
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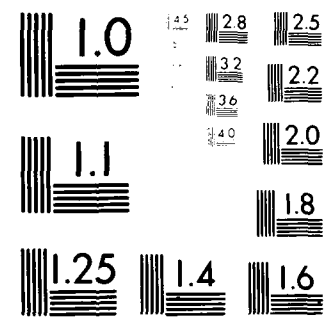
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2 of 3  
AD-A088 730



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CONT



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

4. Referencing your answers to questions 1 and 2; with multi-engine simulators and aircraft (non-centerline thrust) used in UPT, which training should be taught there?

How would this benefit your school?

5. If UPT were taught in conformance with your answers to 4 above, (with multi-engine simulators and aircraft), please circle the number below which best describes how those UPT graduates would be prepared for your school.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

6. Are there any planned changes to your present training program?

7. Do you have any training resources/equipment which could be transferred to UPT?

8. Please state your opinions about dual track training (vs. generalized pilot training).

### ACADEMIC PILOT QUESTIONNAIRE

This questionnaire has been developed to assist in the identification of pilot training requirements for ATC. The information will be used in the development of a tanker/transport/bomber pilot course as a part of UPT. Please take your time and answer the questions thoroughly and conscientiously. Thank you very much for your time and constructive suggestions.

Base \_\_\_\_\_ Assigned aircraft \_\_\_\_\_

Name (optional) \_\_\_\_\_ Rank \_\_\_\_\_

Class number and date graduated UPT \_\_\_\_\_

Date you entered training at this base \_\_\_\_\_

Today's date \_\_\_\_\_

1. Please circle the number below which best describes how UPT prepared you for your present academic training.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

2. Which courses were your least prepared for?

3. Which courses did UPT best prepare you for?

4. In UPT, what training did you receive that deserves more emphasis?

5. What additional training subjects could have been taught at UPT to better prepare you for your present academic courses?

6. At UPT, what academic training did you receive that was not of benefit during your present academic training?

7. Of the academic courses you have taken at this base:

a. Which were the most difficult for you?

b. Why?

c. Which were the easiest?

d. Why?

### PILOT QUESTIONNAIRE

This questionnaire has been developed to assist in the identification of pilot training requirements for ATC. The information will be used in the development of a Tanker/Transport/Bomber pilot course as a part of UPT. Please take your time and answer the questions thoroughly and conscientiously. Thank you very much for your time and constructive suggestions.

Base \_\_\_\_\_ Assigned Aircraft \_\_\_\_\_

Name (optional) \_\_\_\_\_ Rank \_\_\_\_\_

Class number and date graduated UPT \_\_\_\_\_

Date you entered training at this base \_\_\_\_\_

Number of flights here \_\_\_\_\_ Today's date \_\_\_\_\_

1. Please circle the number below which best describes how UPT prepared you for your present academic training.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

2. Circle the number below which best describes how UPT prepared you for your present flying training.

1. Excellent preparation

3. Fair preparation

2. Good preparation

4. Poor preparation

3. From the list below, check the UPT training areas which have been of most benefit to you, some benefit, and no benefit.

MOST	SOME	NO	GENERAL
_____	_____	_____	1. Use FLIP, NOTAMS, & Weather Data
_____	_____	_____	2. Use Nav Charts & DD Form 175
_____	_____	_____	3. Use Performance Data Charts & Equip.
_____	_____	_____	4. Inspect & Use A/C Systems & Equip.
_____	_____	_____	5. Ground Operations
			CONTACT
_____	_____	_____	6. Takeoff, Climb & Level Off
_____	_____	_____	7. Stall Maneuvers
_____	_____	_____	8. Chandelles, Lazy Eights
_____	_____	_____	9. Aerobatic Maneuvers
_____	_____	_____	10. Descent & Traffic Entry
_____	_____	_____	11. Normal Overhead Pattern & Landing
_____	_____	_____	12. Sim Single Engine Pattern & Ldg.
_____	_____	_____	13. No Flap Pattern & Landing
_____	_____	_____	14. Straight-In Approach & Landing
_____	_____	_____	15. Closed Pattern
			NAVIGATION
_____	_____	_____	16. Route & Chart Preparation
_____	_____	_____	17. Dead Reckoning Techniques
_____	_____	_____	18. Low Altitude VFR
_____	_____	_____	19. IFR Techniques
_____	_____	_____	20. VFR Arrival Procedures
_____	_____	_____	21. Flight Termination Procedures
_____	_____	_____	22. Use of AF Form 70
_____	_____	_____	23. ADF, VOR, UHF/DF Procedure Knowledge.

MOST	SOME	NO	INSTRUMENTS
_____	_____	_____	24. Instrument Takeoff
_____	_____	_____	25. Departure, Climb & Level Off
_____	_____	_____	26. Basic Maneuvers
_____	_____	_____	27. Confidence Maneuvers
_____	_____	_____	28. Unusual Attitudes
_____	_____	_____	29. TACAN Procedures
_____	_____	_____	30. Low Altitude Approach Procedures
_____	_____	_____	31. RADAR Approach ASR/PAR
_____	_____	_____	32. ILS Approach
_____	_____	_____	33. Circling Approach
_____	_____	_____	34. Missed Approach
_____	_____	_____	35. Voice Procedures

			FORMATION
_____	_____	_____	36. Takeoff, Climb & Level Off
_____	_____	_____	37. Fingertip
_____	_____	_____	38. Route
_____	_____	_____	39. Trail
_____	_____	_____	40. Echelon
_____	_____	_____	41. Rejoins
_____	_____	_____	42. Penetration/Approaches
_____	_____	_____	43. Overhead Pattern & Landings
_____	_____	_____	44. Wing Landings
_____	_____	_____	45. Use of Visual Signals

			GENERAL
_____	_____	_____	46. End of Flight Reports, Form 781

4. Please list any training received at UPT (and not listed above) which was not beneficial.

5. What training did you not receive in UPT that would have been valuable as a prerequisite for this school?
  
6. In UPT, what training did you receive that deserved more emphasis?
  
7. Of the academic courses taught at this base,
  - a. Which were the most difficult for you?
  
  - b. Which were the easiest?
  
  - c. Why?
  
8.
  - a. Which areas of flight line instruction received here were the most difficult for you? (Besides listing any flight maneuvers, consider all tasks performed, e.g., check list pacing, crew coordination, communications, etc.)
  
  - b. Why?
  
  - c. Which of these areas were taught in UPT?
  
  - d. List the ones that gave you trouble in UPT.

9. a. Which areas of flight instruction received here were the easiest?
- b. Which of these were easy because they were taught in UPT?
- c. Which of these were not taught in UPT?
10. If someone were just entering UPT and would be coming to this school, what constructive suggestions would you make to him?
11. a. How would you change the present UPT training program?
- b. Why?

12. Check the choice that best applies to you. I know what duties are being performed

<input type="checkbox"/> all		<input type="checkbox"/> all
<input type="checkbox"/> most		<input type="checkbox"/> most
by <input type="checkbox"/> some	of the other crew members during	<input type="checkbox"/> some of the flight.
<input type="checkbox"/> none		<input type="checkbox"/> none

13. I think the other crew members

<input type="checkbox"/> all		<input type="checkbox"/> all
<input type="checkbox"/> most		<input type="checkbox"/> most
know <input type="checkbox"/> some	of my duties during	<input type="checkbox"/> some of the flight.
<input type="checkbox"/> none		<input type="checkbox"/> none

14. For this question assume you know everyone else's duties:

I am proficient enough at this phase of my training to assist the

	<input type="checkbox"/> all	
	<input type="checkbox"/> most	
other crew members during		<input type="checkbox"/> of the flight.
	<input type="checkbox"/> some	
	<input type="checkbox"/> none	

15. For this question assume the other crew members know all of your duties:

	<input type="checkbox"/> all	
	<input type="checkbox"/> most	
I think that <input type="checkbox"/> some	of the other crew membes are proficient enough	
<input type="checkbox"/> none		

	<input type="checkbox"/> all	
	<input type="checkbox"/> most	
in their own jobs to assist me		<input type="checkbox"/> of the time I need it.
	<input type="checkbox"/> some	
	<input type="checkbox"/> none	

16. Rate your own ability in crew coordination.

\_\_\_\_\_ Excellent

\_\_\_\_\_ Fair

\_\_\_\_\_ Good

\_\_\_\_\_ Poor

The next four questions relate to subjects which might be taught in different places and with different media. For each of these questions assume that UPT had access to multi-engine simulators and non-centerline thrust training aircraft. For each subject, check the places and media where you think it could best be taught.

17. a. Where would you teach crew coordination? Check one or both of the following:

UPT

Advanced Training

b. How would you teach crew coordination:

Academics (if this is your choice, check one or more of the following instructional methods and media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CPT

CFT

Other (please explain)

Simulators

Aircraft

c. Where and how is it now taught?

18. a. Where would you teach checklist usage and pacing? Check one or both of the following:

UPT

Advanced Training

- b. How would you teach checklist usage and pacing?

Academics (if this is your choice, check one or more of the following instructional methods and media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

- c. Where and how is this now taught?

19. a. Where would you teach radio/interphone communications? Check one or both.

UPT

Advanced Training

- b. How would you teach communications?

Academics (if this is your choice, check one or more of the following instructional methods and media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

- c. Where and how is this now taught?

20. a. Where would you teach asymmetrical thrust flying and associated skills? Check one or both of the following:

UPT

Advanced Training

- b. How would you teach these areas?

Academics (if this is your choice, check one or more of the following instructional methods and media)

Platform instructor

Text books or other written material

Sound/Slide

Videotape

PTT

CFT

CPT

Other (please explain)

Simulators

Aircraft

- c. Where and how is this now taught?

21. a. Assuming you could have a multi-engine (non-centerline thrust) aircraft, motion simulators and any other training devices you wanted, what changes would you make in UPT?

- b. How would these changes have helped you?

## INTERVIEW CHECKLIST

1. Crew Coordination - is a difficult concept to get a handle on. However, later on in this contract we have to deal with crew coordination, primarily from the aspect of how it can best be trained. It would be extremely helpful to us on this later phase, if we could explore this issue now. Perhaps it would provide us with some new ideas or help us refine our current thinking.
  - a. First, as a group, can we define crew coordination, or, perhaps, list the important elements of crew coordination. Let's try for a definition or description that everyone can agree on.
  - b. Next, how, and in which medium does the student presently get most of his training in crew coordination.
  - c. Other than actually flying with an aircrew or in simulators, are there any particular training areas or tasks which have a high payoff for crew coordination; that is, ground-based tasks or skills which exercise crew coordination?
  - d. How do you know when a student is proficient in crew coordination? That is, how do you measure crew coordination?

2. Generalizability - Generalizability is roughly equivalent to transfer of training. That is, a task is generalizable if the student can practice it in one medium (e.g., simulator) and later, perform it well in another medium (e.g., aircraft). Another way to look at it is: the student learns a skill in UPT, flying one type of aircraft, and can perform a similar skill here, in CTS, in a different type of aircraft.
- a. Which training areas, training tasks, knowledges or skills have the highest payoff for transfer from one medium to another: e.g., simulator to aircraft?
  - b. Which training areas, training tasks, knowledges or skills have the least payoff for transfer from one medium to another?
  - c. Which training areas, training tasks, knowledges or skills have the highest payoff from transfer from one level of training to another: e.g., UPT to advanced?
  - d. Which training areas, training tasks, knowledges or skills have the least payoff for transfer from one level of training to another?
  - e. Are students introduced to training areas, items, knowledges or skills here that you think would be better introduced in UPT, i.e., areas, items, etc., with high transfer?
  - f. Are students first exposed to areas, etc. in UPT that you think should wait until they reach this (advanced) level of training; i.e., items or areas which don't transfer well?
  - g. What is the best example, that we can all agree upon, of a task or item with good transfer, either from one medium to another or from one level to another?

3. Proficiency Levels - a later phase of the contract also wants us to have a look at performance standards/proficiency levels in a very top level or broad sense of the word. Conditions and standards are usually stated at the micro-task level; for example, "set such and so radio to such and so frequency at such and so time after takeoff. Do it within 3-5 seconds." We are concerned with a much broader level than this - "Be able to operate your radio - in flight - so that mission progress and safety are not hampered, or, so that messages get through in a timely fashion."

a. How well do recent UPT graduates perform in the following areas? Let's use a 2 or 3 point scale - 1 means he is totally unprepared in a multi-engine environment, 2 means he knows something, etc. For reference, if we extrapolated the scale, 5 would represent a line pilot and 7 an I.P.):

_____	_____	_____	Mission Planning
_____	_____	_____	Crew Briefings
_____	_____	_____	Aircraft Systems
_____	_____	_____	Communications - Making required calls, hearing
_____	_____	_____	all interphone and radio transmissions and re-
			sponding
_____	_____	_____	Decision Making
_____	_____	_____	Crew Coordination
_____	_____	_____	Checklist usage and pacing
_____	_____	_____	Knowledge of Instrument procedures
_____	_____	_____	Asymmetrical thrust
_____	_____	_____	Maintaining proper azimuth on another aircraft
_____	_____	_____	Maintaining proper elevation on another aircraft
_____	_____	_____	Being able to close on another aircraft
_____	_____	_____	Normal procedures
_____	_____	_____	Emergency procedures
_____	_____	_____	Instrument flying
_____	_____	_____	Navigation
_____	_____	_____	Takeoffs
_____	_____	_____	Landings
_____	_____	_____	VMC traffic transition flying

b. How well should he be able to perform to get the most benefit out of your training program here, using the same scale as before?

_____	_____	_____	Mission Planning
_____	_____	_____	Crew Briefings
_____	_____	_____	Aircraft Systems
_____	_____	_____	Communications - Making required calls, hearing
_____	_____	_____	all interphone and radio transmissions and re-
			sponding
_____	_____	_____	Decision Making
_____	_____	_____	Crew Coordination
_____	_____	_____	Checklist usage and pacing
_____	_____	_____	Knowledge of Instrument procedures
_____	_____	_____	Asymmetrical thrust
_____	_____	_____	Maintaining proper azimuth on another aircraft
_____	_____	_____	Maintaining proper elevation on another aircraft
_____	_____	_____	Being able to close on another aircraft
_____	_____	_____	Normal procedures
_____	_____	_____	Emergency procedures
_____	_____	_____	Instrument flying
_____	_____	_____	Navigation
_____	_____	_____	Takeoffs
_____	_____	_____	Landings
_____	_____	_____	VMC traffic transition flying

- c. The AF has recently purchased some computer-based systems for automatically scoring and grading performance. These systems usually bootstrap to existing simulators. What types of checkride items would be amenable to this sort of scoring and grading? - Why?
- d. What types of checkride items would you prefer to see graded by an I.P. or Stan/Eval? - Why?
- e. What types of ground-based flight training would be amenable to automatic scoring and grading? ~ Why?
- f. What types of ground-based flight training would you prefer to see graded by an I.P.? - Why?

4. Judgment and decision-making capabilities are areas in which the pilot must be proficient, yet are also very difficult to get a handle on. If possible, let's try to reach agreement on the following issues:
- a. Can we define, for a pilot, what constitutes good judgment and good decision-making capabilities?
  - b. How can judgment and decision-making be taught?
  - c. Where can judgment and decision-making be taught?
  - d. Two elements of judgment and decision-making are the ability to prioritize tasks, especially in an emergency, and the ability to execute tasks.
    - 1. Can we elaborate on prioritizing tasks and executing tasks? Your ideas?
    - 2. In addition to the elements we just discussed, do you think there are other important elements or facets of decision-making?

## APPENDIX B

### RESPONSES TO QUESTIONS

Appendix B provides responses to selected questions which were administered and compiled during this study.

When questioned as to what brings about good crew coordination, the instructors at the different CCTS had similar responses. Their answers seem to indicate that for good crew coordination, the crew members must: (1) be competent in their own jobs, (2) be knowledgeable of all aspects of the mission, (3) be knowledgeable of what the other crew members are doing, (4) understanding when they need assistance, and (5) what assistance they need. (Note: being competent in one's job includes being able to communicate and command a checklist.) One of the most difficult tasks to train and the last item the crew members become proficient in is crew coordination. Interviews indicated that student crew members become so absorbed in performing their own duties that they become oblivious to the radios and the needs of others. Each action point is a surprise and coordination between student crew members is almost non-existent. Some instructors felt the tasks above could be analyzed into sub-tasks, and education and training requirements could be derived. Ground courses in mission profile could be built and some experience taught. The instructors also noted that in the affective areas, a student needed to be motivated and have the desire to excel and to help others.

Comments are given below, by specific aircraft for the questions compiled during the on site interviews.

Q: Based on your experience, what are the factors which bring about good crew coordination:

B-52

\* "Discipline, planning, knowledge, judgment

1. Any action a crew member might take to eliminate confusion at any time.
2. Preparing mentally and physically to anticipate decisions and actions throughout the flight.
3. Any act that a crew member might perform to ease or simplify another crew member's tasks during any portion of the flight.
4. Any verbal response, question, or action that a crew member might do to ensure or increase the safety and effectiveness of the flight."

\* "Experience"

\* "When each individual starts to become familiar with his task, crew coordination then starts to improve. Crew Coordination is a direct variable of how a student understands his tasks and if he feels comfortable performing those tasks. And when you have 4 instructors

trying to teach their techniques and 6 students trying to acknowledge and/or do their assigned duties on a single interphone channel — it is chaos. Crew Coordination is only as strong as the weakest link. Only when an individual understands and can accomplish his task satisfactorily will he start to appreciate and understand the tasks other individuals have to perform on the airplane. It is at this point where crew coordination starts to improve."

- \* "Job knowledge and familiarity with the other crew member's duties. One single overriding factor is experience level. Understanding the needs and requirements of other crew positions — preparation, anticipation, and concentration. Knowledge of own duties — knowledge of other crew members' duties — good mission planning."
- \* "Knowledge of other crew duties — realization that one individual cannot do the job by himself (or herself)."
- \* "Good prebriefings and critiques. Listening up on radios and UHF (all crew members)."
- \* "Communication and interaction with other crew members. Prior mission preparation is essential on the ground-prebrief."
- \* "In-depth knowledge of mission objective. Familiarity with duties of every crew position."

- \* "Experience only - trial and error (percent system). CFIC is the only academic place in SAC CC is presently taught. From a seminar we can compile many techniques for CC and then experiment to find ones which suit particular situations/crew members. Lists-texts-examples."
  
- \* "A good working knowledge of:
  1. The mission
  2. Your job
  3. Your fellow crew members' jobs"
  
- \* "Knowing your job. Knowing how other crew members interact with your job. Practice."
  
- \* "Prebriefing-flying-critique"
  
- \* "Exposure, experience, knowledge of procedures, knowing what you're listening to (experience)."
  
- \* "Interaction between crew members of higher experience and newer students. Thorough table flying of each mission."
  
- \* "Knowing what you have to do and in what time frame. Knowing that you have other crew members with you that also have a job to do. Knowing the limitations of your particular communications system,

i.e., interphone, radios, etc. Knowing that you have to work as a team to produce successful results."

- \* "The individual having a good understanding of the other crew members' tasks and responsibilities."
- \* "Basic knowledge of checklist and procedures. Basic skills necessary to fly the mission (minimum requirements). This is minimum to allow the student to not be totally involved in the above."
- \* "Basic knowledge of what needs to be done. Knowledge of what other crew members are doing. Knowledge of options at any given time. Anticipation of potential problem areas. Decision-making capability."
- \* "Empathy"
- \* "Understanding and anticipating the needs of the other crew members to complete their portion of the mission."
- \* "Experience — knowledge of other crew members' jobs."
- \* "A good knowledge of your job. A good knowledge of your mission. A working knowledge of the other specialities' jobs. The ability to communicate."

KC-135

- \* Knowledge of other crew members' duties."

- \* "Experience, excellent knowledge of all aircraft procedures and systems. Good working knowledge of all other crew members' procedures in that aircraft."
- \* "Experience with an integral crew. A general understanding of other crew member duties. In training (at CFIC) we allow instructor candidates to perform some of the other crew member duties to enhance this understanding."
- \* "Understand and knowing your functions, also be familiar with other crew member functions. Therefore, be aware of the surrounding situation. Help out the other crew members when possible. Don't have to be told when to do different items. Keep ahead and do all that can be done. Anything else which needs to be accomplished."
- \* "Basic knowledge of other crew members' duties and specific phases of flight. This is gained in the eight instructional rides at the SAC CCTS for the most part. Accomplished with instruction by flight line instructors and general 'rap' or 'hanger flying' sessions."
- \* "Knowing your own job and responsibilities, those of others on the crew, and being able to foresee what will happen and what may happen... so as to assure safe and procedurally correct completion of the mission — regardless of what happens."
- \* "Repetition and understanding of how and why each item is required."

- \* "A basic understanding of what crew coordination is and when it is required. However, the hardest and probably the key is teaching new UPT graduates that it takes two pilots, working together, to fly the KC-135. It's hard to stop them from trying to accomplish everything themselves."
- \* "Good pre-mission briefings. Controlled training flights. Good post-mission debriefings. Well organized CPT and WST."
- \* "Rank order: (1) Knowledge of procedures, (2) communication (listening and responding to ATC communications), (3) use of interphone, (4) scant knowledge of what other crew members are doing at a particular time, i.e., his/her checklist requirements."
- \* "Exposure"
- \* "Personal job knowledge of individuals' crew position and how individuals' actions interrelate with other crew positions. Being ready to go fly. Having priorities set prior to flight, i.e., crew commander must go through this with crew prior to flight. Plan ahead for contingencies. Pacing."
- \* "The individual's attitude. He has to be told that good crew coordination is not written. Only guidelines. I instruct the student to constantly plan ahead. Mentally fly the A/C even if his hands are not on the yoke. If the other pilot has to ask for something, the

other pilot is not fully doing his job. I instill in the pilots that effective coordination is imperative for the safety of the mission. It's a full time job."

- \* "Practice and actually accomplishing crew coordination with the entire crew. And knowing what the other crew position duties are."
- \* "Knowing what is required of each crew member and time required to accomplish each task. Pacing — knowing what will be coming up and being ready to perform task."
- \* "A general knowledge of other crew member's functions and duties. Elimination of parochial attitude in performing flight duties. Planning, prior to flight, who will do specific tasks inflight, i.e., who will talk on radios, who will be responsible for flight logs, navigation, etc., etc."
- \* "Prior experience and knowledge of other crew member duties and requirements."
- \* "Mission planning — Identify/know action points and preplan actual responsibilities, priorities, and sequence. Procedural knowledge — Know your own job/familiarity with other crew duties/responsibilities. Good use of CPT — Incorporate other crew positions and E.P.'s as proficiency is gained."

- \* "Standardization — crew proficiency and qualification."
- \* "Standardization"
- \* "Working with a crew making decisions and completing procedures requiring coordination with other crew members. Working under pressure in simulator to recognize, analyze, and accomplish proper procedures works best."
- \* "Knowledge of required crew duties. Time in crew situation. Environment which allows student to work on crew coordination while not necessarily being the pilot flying the aircraft. This allows position reporting, communications procedures."
- \* "Experience with flying a crew controlled aircraft."
- \* "First, the student must be taught what crew coordination is, especially if he or she has never flown as a crew. He must know exactly what his responsibilities are as a CP and then do them well all the time, not just when he gets a checkride. He must also know why he performs."
- \* "Actual experience of working with and requiring crew coordinated decisions."

- \* "Demonstrated need for it (Ex. malfunctions, etc.) — Exposure to others' experience — Practice."
- \* "An aggressive copilot who demands that checklist responses are accomplished exactly as written. Ensures the checklist continues until completion."
- \* "Training, trust, good interphone system."
- \* "Copilots that know the regulations and are not intimidated by 'old-head' ACs and NAVs. If they have confidence they will question mistakes."
- \* "Good attitude and a hard instructor."

C-141

- \* "Knowledge of systems — knowledge and use of checklists. How the aircraft commander uses his authority."
- \* "Exposure"
- \* "Practice"
- \* "Experience"

- \* "No. 1 is being with a crew rather than flying solo. All crew members proficient in their assigned duties and a willingness to rely on other people."
- \* "Talking to one another. Pilot not trying to fly 'solo'."
- \* "Practice and realization that more than one person on the airplane."
- \* "Knowledge of aircraft systems and procedures. The making use of all available crew members to assist the pilot flying the aircraft. A knowledge of mission objectives and the delegating of tasks to accomplish these objectives efficiently and safely."
- \* "An understanding of what each crew member does. An attitude that the aircraft is not to be flown solo and that the crew has to work as a team with each person backing up the other crew members. Practice in working with other people during flight."
- \* "Exceptional systems knowledge — an aircraft commander with self-confidence who is not afraid to LEAD."
- \* "A knowledge of procedures. Experience with procedure (i.e. practice)."

\* "Respect for the knowledge and expertise of the other crew members and willingness to coordinate with these crew members before making a decision."

\* "Experience"

\* "Knowledge of what other crew positions are doing — not how but what.

1. A solid knowledge of one's duties
2. A basic understanding of other crew member duties
3. Standardization of procedures
4. A well written and useful checklist
5. A realistic training environment
6. Professionalism on the part of the instructors"

Response frequencies were tallied and converted to percentages for the item:

"Listed below are some training areas in which UPT students may encounter difficulty. If you have found that an area is a very difficult one for the students, put V beside it. If it is moderately difficult, put M beside it. If it just causes some difficulty, put S beside it. If it causes no

difficulty, leave the item blank. If it is not in your training syllabus, put N/A beside it."

The listed training areas covered all major areas of CCTS training for which the student pilot is responsible. Response categories were very difficult, some difficulty, no difficulty, and N/A.

B-52 instructors judged communications, decision-making, crew coordination and asymmetrical thrust as very difficult for their student. They judged mission planning, aircraft systems, checklist usage and pacing, asymmetrical thrust and landings as being moderately difficult (equal numbers of instructors selected very difficult and moderately difficult for asymmetrical thrust). They judged knowledge of instrument procedures, instrument flying and navigation as causing no difficulty.

C-141 instructors were split on two areas. A large percentage judged decision making and crew coordination to be very difficult and an equal number selected them to be moderately difficult. None of the training areas listed were judged to cause no difficulty, with most areas being judged moderately difficult.

C-130 instructors judged aircraft systems, communications, decision making, crew coordination and landings to be very difficult. Decision making (equal number selected as very difficult) and asymmetrical thrust are considered moderately difficult. Only takeoffs were judged to be of no difficulty, with an equal number putting takeoffs into the some difficulty category.

KC-135 instructors judged only crew coordination to be very difficult. They judged communications, decision-making and checklist usage and pacing to be moderately difficult. Normal procedures, takeoffs and VMC traffic transition were judged to cause no difficulty.

Two C-9 instructors were interviewed. They considered mission planning, decision making, knowledge of instrument procedures and landings to be very difficult. Normal procedures, instrument flying and takeoffs were judged moderately difficult. None of the areas were considered to cause no difficulty.

Two training areas were almost universally considered N/A. These were maintaining (1) azimuth and (2) elevation on another aircraft. Being able to close on another aircraft was judged to cause some difficulty by B-52 and KC-135 instructors. Other instructors judged this training area to be N/A. Similarities and differences in instructors' response patterns may be seen in the chart on the following page.

To explain the chart, each entry corresponds to the highest response frequency for that aircraft type for the training area. For example, for the mission planning training area, the most frequent response for C-9 instructors was very difficult. For B-52 instructors the most frequent response was moderately difficult. The most frequent response for C-130 and KC-135 instructors was some difficulty. Empty cells indicate that no instructor group selected the response category most frequently.

CHART B-1. Level of Difficulty

	<u>V</u>	<u>M</u>	<u>S</u>	<u>BL</u>	<u>N/A</u>
Mission Planning	C-9	B-52	C-130, KC-135		
Crew Briefings			B-52, C-130 KC-135		
Aircraft Systems	C-130	B-52			
Communications	B-52, C-130	KC-135	KC-135, C-9		
Decision Making	B-52, C-141, C-130, C-9	C-130, KC-135			
Crew Coordination	B-52, C-141, C-130, KC-135				
Checklist usage/ pacing		B-52, KC-135	C-130, C-9		
Knowledge of instru- ment procedures	C-9		C-141, C-130, KC-135	B-52	
Asymmetrical Thrust	B-52	B-52, C-130	C-141, KC-135		C-9
Azimuth			B-52, KC-135		B-52, C-141, C-130, C-9
Elevation			KC-135		B-52, C-141, C-130, C-9
Close			B-52, KC-135		C-130, C-9, C-141
Normal Procedures		C-9	B-52, C-141, C-130	KC-135	
Emergency Procedures			B-52, C-141, C-130, KC-135		
Instrument Fly		C-9	B-52, C-141, C-130, KC-135		
Navigation			C-141, C-130, KC-135	B-52	
Takeoffs		C-9	B-52, C-141, C-130	C-130, KC-135	
Landings	C-130, C-9	B-52	C-130, KC-135		
VMC traffic transition			B-52, C-141, C-130	KC-135	

Based on this chart, the two training areas viewed as very difficult by most instructors are decision making and crew coordination. Only moderate agreement occurred among the instructor groups regarding which areas are moderately difficult. Greatest agreement occurred on training areas of some difficulty, as indicated by three to four of the five instructor group responses in a large number of the cells of the chart. Finally, most instructors indicated that maintaining azimuth and elevation on another aircraft were not applicable to their training syllabus (four out of five instructor groups). Three of the five groups indicated that being able to close on another aircraft was not applicable to their syllabus. With regard to maintaining azimuth and elevation and being able to close on another aircraft it is believed that these items were misunderstood by the instructors. They were intended to encompass the skills involved in both cell formation and air refueling training.

Instructor responses to Q. "How would you change the present UPT training program?" were varied. The responses ranged from "It's O.K. the way it is," and "I see no reason to change UPT" all the way to definite advocacy of some type of dual track training. By aircraft, the breakdown of instructors advocating dual track is as follows:

KC-135	59%
C-130:	25%
C-141:	50%
B-52:	13%

Instructors who directly advocate dual track in UPT frequently mention various tradeoffs which might be made during UPT. Among these are:

- more instrument flying - less contact;
- more navigation - less formation;

Aerobatics are also frequently mentioned, with some instructors advocating dropping it from the UPT curriculum for "heavies," and others mentioning the confidence aerobatics instill in the student.

The most serious concern of all the instructor pilots was the aptitude/psychomotor testing and the screening and selection system to be used in the TTB, FAR track student placement.

In response to the questions:

Q: How would you change the present UPT training program?

Q: Why?

The recent graduates answered:

C-130

\* "More cross country solo time."

- \* "Do not divide into tracks until at least 1/2 way through T-38. More solo time (cross country, etc.)."
- \* "Put an ADF in either the T-38, T-37 or get a simulator with one."
- \* "Put more systems emphasis throughout 37 & 38 phase rather than just at the start."
- \* "For those selected for heavies cut T-38 program in half, and spend much more time in the A/C doing actual approaches and instrument flying. Have assignments come down at the end of the T-37 phase of flight."
- \* "Take away the simulators-and give more out & backs. The hardest thing in flying is communicating & the UPT profiles are too canned."
- \* "The current swing in UPT is to do everything, particularly all instrument work, in the simulator to save money. Well, I have learned that nothing beats actual hands-on flying in the real aircraft."
- \* "More emphasis on regs."
- \* "I would add more solo cross country time."
- \* "Pretty applicable to any aircraft training. No changes, no complaints."
- \* "I liked the T-38. The experience was good even though I am now in a 130. Don't change it."

KC-135

- \* "Loosen it up. Make it less restrictive. Give the IP more options on how and what to teach."
- \* "More cross country time."

- \* "Assignment selection would be by order of merit."
- \* "Try to get more out and backs and cross country's to get away from canned radio procedures, and more experience in using FLIP, G.P."
- \* "Have some instrument rides in the aircraft."
- \* "Use the link trainer as an introductory cockpit familiarization trainer only. There is too much of a difference between the simulator and the aircraft, plus the added problem of disorientation in the back of a T-38. Link is worthless as a flying training aid."
- \* "Put real controllers & real situations in the simulator. Have controllers clear you different than filed. Get vectors for traffic, etc. It's not realistic to have your own personal controller and a situation that never changes."
- \* "Improve T-37 instruments (use a flight director) and extend the T-37 program with emphasis on instrument procedures for 'heavy' assignees."
- \* "I felt the training at UPT was very good. However, there was not enough emphasis and too few missions on instrument procedures. I would ask for many more instrument missions (keep in mind I did not have flight simulators). I feel that no matter what command a pilot goes to, he must have a thorough knowledge of instruments. In addition, he must have confidence in his abilities. More sorties in UPT would contribute to this."
- \* "More navigation training, you have to get there to do the mission."
- \* "Shorten it and specialize for aircraft category chosen by student. Let the student choose his type aircraft earlier. The student will

have a definite goal to work for, be more ready for his new assignment, and not study unneeded areas."

- \* "I was taught solely on simulators for all instrument training (both T-37 and T-38). I would put some actual aircraft instrument rides back in the program (besides the one cross country). To expose the pilot to real world handling, atmospheric conditions on the radio, aircraft instruments (CDI) operation (how it fluctuates) as opposed to the simulator (always locked on and steady).
- \* "I would not."
- \* "Dual track after T-37's should be given serious consideration. Though I very much enjoyed flying T-38's in formation, I have no use for it now. UPT is currently directed toward fighter type flying only."
- \* "Give some type of instruction in crew coordination. This seems to be the hardest aspect in learning to fly heavies, besides their particular procedures."
- \* "A little more exposure to what a heavy aircraft copilot might expect to see."
- \* "Dual track program. As a KC-135 pilot I need little to no knowledge of tactical formation, very minimal training in formation, and some knowledge in contact maneuvers."
- \* "Consider adding a team out and back mission, possibly at the expense of 1 or 2 local instrument sorties. Two student pilots could then combine instrument/navigation training with crew coordination. I would not favor reducing the present number of contact or formation training flights."

- \* "Except for basic familiarization flight or two, delete formation flights for students going to aircraft which do not fly formation."
- \* "No change" as is, it's efficient, cost-effective, and adequate. The large amounts of man power and tax dollars required to revise the program and develop it do not provide marginal benefits equivalent to the marginal costs. Also, the short term pilot product of the transition period would suffer in quality."
- \* "I think that the present UPT system is outstanding. It allows an individual to experience the entire realm of flight (i.e., aerobatic maneuvers, inst.). This training in turn allows the individual to establish a reference for his own personal limits."

B-52

- \* "I would drop some of the contact and aerobatic maneuvers and concentrate more on instrument work and low-level navigation and bombing technique. I feel that UPT students should go out of the local flying area more often so as to build their understanding of normal flying operations and to increase their experience level. Also, UPT students should be pushed to fly the whole mission. This does not include having instructors take the stick after transition at an out base and fly it back to altitude."
- \* "Valuable student experience is lost by local area only sorties and departure and arrival by instructors at out bases."
- \* "Go to a dual system - Fighters and Heavies. Although I enjoyed the UPT program, only one-third was anywhere near what I had to learn

here; instrument, contact and formation do not help in learning how to fly a B-52."

- \* "More low-level. Low-level is the reason Buff's fly. The low-level in UPT was a fun 4 rides, with emphasis on looking at the cars on the ground. Emphasis should be placed on accomplishing tasks (timing, checklists, route) during low-level."
- \* "I would have more instrument work, and if someone knows he is going to a heavy, some heavy time. It's impossible to practice crew coordination with a two-man crew."
- \* "Have separate track for heavies and fighters. Transition to yoke flying and slow aircraft response is difficult."
- \* "Give all pilots the same training (Don't drop wing landings for pilots going to heavies. Because UPT pilots are competent no matter what their assignment and it's insulting to deny them formation training 'because they don't need it'. (i.e., only fighter assigned students got extra wing landings and formation.) The attitude was 'we don't have time to waste on you heavy pilots,' or 'you're not ever going to need this.'"
- \* "I would not change it."
- \* "Some method of assigning aircraft which considers ability (more than FAR categorization). Less qualified FAR students get fighters. More qualified FAR students get bombers."
- \* "Have more out & backs. Fly instruments as much as possible. Instrument flying is the most transferrable skill learned in UPT."

C-9

- \* "I would not change UPT, but instead add a heavy course and a fighter tactics course for the pilots who go to the respective areas of flight. It would help the transition. In conclusion: All aspects of pilot training are important for total pilot development in my opinion, even though some of it isn't directly related to the C-9. However, basic heavy maneuvers along with flight knowledge of the heavy aircraft should be added to a UPT course for all heavy pilots such as enroute procedures, fuel planning, thrust reverse, etc; those items that would be directly related to transport pilots. Also, more knowledge about cross country flights, and different airfields is needed out of UPT."
- \* "I would not change UPT. You need to learn to fly & then you can learn another A/C and smooth out your skills. No change."
- \* "In addition to aircraft, add motion simulators to increase proficiency. In more varied environments and conditions not possible to simulate in the aircraft to enable the pilot to at least experience an emergency situation under 'safe' conditions."

Q: If someone were just entering UPT and would be coming to this school, what constructive suggestions would you make to him?

C-130

- \* "None, no UPT preparation for the C-130 can be made."

- \* "Concentrate on instrument procedures and memorize rules."
- \* "Learn RMI only procedures."
- \* "Study instruments and terps (51-37)."
- \* "Be flexible and keep an open mind."
- \* "Spend more time on low altitude approaches and try to develop some crew coordination (if possible) in UPT."
- \* "Be prepared to study because there is a lot to learn. This school, particularly phase II, can be a lot of fun after the procedures are learned."
- \* "Learn basic regs (60-16, 51-17 etc.) well."
- \* "Try to do the best you can in the training aircraft and learn as much as you can about that aircraft. It will make it much easier to learn about your operational aircraft."
- \* "Get in the books and don't get discouraged."
- \* "Fly wider downwinds - learn ADF."

KC-135

- \* "Things get better when you get out of ATC (i.e. procedures techniques are looser and seem to have a reason) and flying is much more motivational out of UPT so don't get too demotivated."
- \* "Learn systems, instruments, crew coordination."
- \* "Use of checklist in a crew environment. Become as proficient as possible in radio communications, especially during out and backs and cross country where you are away from canned radio procedures. Try to get as much experience as possible shooting single engine

approaches, to help instill techniques necessary when using asymmetrical thrust. Try to establish in your mind a pacing for different phases of flight, (i.e., T.O., departure, enroute, arrival, landing.)"

- \* "Learn as much as possible about instruments and instrument flying."
- \* "Learn how to help the other pilot. Concentrate on instrument flight rather than contact. Try to get experience talking and coordinating with real controllers."
- \* "T-37 flying characteristics combined with T-38 instruments is required."
- \* "Work at all phases of UPT because you will need those skills as a pilot even though some areas are used more than others. UPT teaches basic skills so don't expect to know advanced techniques."
- \* "Delete most of contact phase after solo-leave just enough for landing currency. Delete formation phase - even though it was fun."
- \* "More emphasis on Nav. and inst. procedures plus checklist and crew duties."
- \* "Learn how to fly instruments, know 60-16 by heart, learn that approaches, penetrations, VOR, TACAN, and radio procedures are your bread and butter."
- \* "Pay attention to mission planning. Learn to pace throughout flight."
- \* "Understand instrument flying completely."
- \* "Study the systems hard and learn the numbers as soon as possible, so that more time can be spent on actual flying mechanics and standard

procedures, since they are the hardest to learn and the most important to know no matter what A/C you fly."

- \* "Concentrate hard on instrument flying."
- \* "Less emphasis on contact maneuvers and formation. More emphasis on instruments, navigation, FLIP procedures/regs."
- \* "Learn instrument and navigation procedures well - they're the same in SAC as in ATC, with some additions."
- \* "Get as much aircraft instrument time as possible."
- \* "Learn your aircraft systems."

B-52

- \* "Put extra emphasis on instrument flights. May be helpful to fly a large aircraft in UPT even if only as an orientation to see what the flight characteristics are and what to expect. Possibly a T-39 flight would provide some insight."
- \* "Place emphasis on instrument procedures. Try to get instructor to help in learning crew coordination."
- \* "Learn all you can about low-level. Ask instructors with B-52 learning experience for more information on the ways to make a good low-level run."
- \* "Learn instrument procedures and learn to work with other crew members. Be prepared to buckle down and study because no matter what you've heard, it's challenging and frustrating. Also, it's not any fun, at least for the first few flights."

- \* "Concentrate on instruments, mission planning, and fix to fix flight. Formation and contact will be of little use except for radio procedures."
- \* "Study up on enroute communications, flight planning requirements, IFR procedures, TACAN and VOR holding, 60-16 requirements. Know how to draw a low-level chart. Know how to give a PIREP and talk to center on UHF. Practice good checklist technique and pacing. Be aggressive on getting things done. This is all minor stuff, but have a good study technique so as to assimilate all the knowledge necessary."
- \* "Work on navigation, and learn how to study, especially emergency procedures."
- \* "S.I.E. unless you really enjoy flying (any type of flying). Concentrate on instrument procedures and FLIP knowledge."
- \* "Work in Instrument flying."

#### C-9

- \* "Learn 60-16, low altitude procedures, TACAN, VOR, ADF, crosswind landings, thunderstorm knowledge."
- \* "Just learn to fly the A/C and in an upgrade program you will learn the specifics of your particular A/C."
- \* "Concentrate on instrument procedures and approaches. Learn that cross country planning and execution require flexibility on the part of the pilot as opposed to "canned" procedures as taught in UPT."

Q: Which areas of flight line instruction received here were the most difficult for you? (Besides listing any flight maneuvers, consider all tasks performed, e.g., check list pacing, crew coordination, communications, etc.)

C-130

- \* "Crew coordination, use of rudder"
- \* "Communications"
- \* "Crew coordination"
- \* "Check list procedures"
- \* "Crew coordination, and approach coordination"
- \* "Landing - different picture"
- \* "Crew coordination, check lists, phase II formation procedures"
- \* "Crew coordination"
- \* "Communications, I had difficulty picking out the important transmissions, and which radio it was on and how to respond"
- \* "Rudder usage and landings"
- \* "Crew coordination"

KC-135

- \* "A/R, I didn't have any A/R background so I didn't know what was going on."
- \* Crew coordination, not emphasized enough in UPT."
- \* Communications, number of radios being handled at one time."

- \* "Crew coordination did not receive the emphasis it deserves for the crew concept in heavies. Communications, too many canned procedures and too few cross countries."
- \* "Crew coordination - HF radio"
- \* "Radio coordination, how to help the other pilot getting back into flying groove. No training in UPT on cooperation between pilots. 4 months between UPT and actual flying."
- \* "Crew coordination/checklist, not exposed to crew concept."
- \* "Learning how to control the ailerons and associated momentum generated by them. I'm used to a much more responsive A/C. Slow cross check, 3 1/2 month layoff without flying."
- \* "Fuel management, never had to do it before, no CG concern."
- \* "Checklist and crew coordination, they were emphasized a lot more."
- \* "Flight line changes at the last minute, the amount of paperwork that must be redone. Crew coordination, at UPT the IP wants you to do it, there is no load sharing. HF communications, first time I was exposed to it."
- \* Communication, 3 different radios to monitor. Landing, difficult until instructor demonstrated landing attitude power on for length of runway."

B-52

- \* "Check list pacing, crew coordination. In UPT check lists were accomplished at once before a maneuver without crew coordination. We

had check list responses but really no type of crew coordination in a 2 seat A/C."

- \* "The most difficult was probably understanding interphone chatter. IN T-38, listening to one person and one radio is much easier than listening to nine people and 3 radios."
- \* "Check list pacing, crew coordination, communications not taught."
- \* "Low-level bombing, crew coordination, check list pacing, endurance."
- \* "Approach and landing and check list pacing. I'm not used to large inputs necessary for small corrections in aircraft attitude."
- \* "Flying was no problem. Crew coordination, enroute flight plan changes. It simply takes experience which one doesn't get on the short flights and 2-man crew requirements in UPT."
- \* "Check list pacing and communications."
- \* "Crew coordination, no prior experience with it in UPT."
- \* "Check list pacing and crew coordination. Both are new and require experience to acquire competence."

C-9

- \* "Check list"
- \* "In upgrade there is no crew coordination."
- \* "Finding switches in response to checklists."

It is interesting to note that at the time of this report, the only formal course of instruction for either SAC or MAC is at SAC's elite Central Flight Instructor's Course (CFIC) and that instruction is only available for instructors. CFIC also has the only structured course on asymmetrical

thrust. The basic CCTSs for all TTB aircraft leave crew coordination, communications and asymmetrical thrust training up to their flight line instructors. It is believed that a basic knowledge of these skills could be taught through tapes and PTTs. The training would be beneficial to both the students and the flight line instructors. An important fact arose in two instances as the reason given for a difficulty in an area - a three to four month layoff occurs between UPT and flying at CCTS. This may not be an initial training problem as much as one of reinforcement.

Even though the instructors and students said that instruments was one of their better trained areas, notice how the students answered the next question. Also, for commonality, note how many different aircraft ask for low altitude procedures.

Q: In UPT, what training did you receive that deserved more emphasis?

C-130

- \* "More emphasis on cross country flying and not so much local area work."
- \* "Low altitude procedures (low altitude approaches)."
- \* "ADF procedures (perhaps a simulator)."
- \* "Terminal procedures"
- \* "Low altitude procedures"
- \* "Low altitude approaches in a real world environment."
- \* "Instruments"
- \* "Low altitude instrument procedures"

- \* "Cross country flights"
- \* "There should be more solo cross country time."
- \* "Not enough emphasis on use of rudder."
- \* "Less acro for heavy drivers - more approaches instead."

KC-135

- \* "Cross country and out and back (i.e., Get away from canned radio calls)."
- \* "More systems emphasis; more cross country."
- \* "General planning, filing, radio procedures (coordination between pilot and ATC)."
- \* "Instruments, 781 and associated paperwork."
- \* "Cross country"
- \* "Some more instrument procedures"
- \* "Instrument understanding (especially in T-37s) and correct usage. Speedy cross check."
- \* "Instruments - flying other than on jet routes. More point-to-point."
- \* "None"
- \* "Navigation"
- \* "Get away from canned approaches and departures. More out base work would build more confidence."
- \* "Instruments"
- \* "None"
- \* "None"

- \* "More aircraft NAV/Instrument missions with emphasis on actual enroute and terminal exposure at strange bases. Local canned procedures are of minimal benefit to the student pilot."
- \* "Instrument/navigation sorties to other bases, i.e., out and back and cross country mission."
- \* "None"
- \* "I feel that the UPT program that I experienced covered all phases of training very well."

B-52

- \* "More enroute procedures and aircraft control at high altitude."
- \* "Perhaps more out and back instrument training and low-level procedures."
- \* "Low-level"
- \* "Use of performance manuals, instrument procedures and crew coordination."
- \* "Most things covered in UPT received more emphasis than they deserved."
- \* "Navigation flying"
- \* "Low-level flights - Dead reckoning techniques"
- \* "Instrument flying in T-38"

- \* "Fuel planning and different types of landings in changing weather environments. Cross country flights."
- \* "Cross country and enroute procedures."

Discussion Interview

The Air Force, in looking at the broader picture of benefits and costs, may wish to consider the following points made by instructor and staff personnel during discussions and interviews.

One, the current UPT graduate is meeting the demands of the TTB CCTSs. MAC and SAC training supervisors at the C-130, KC-135, B-52, C-141 and C-9 advanced training units have been and still are very pleased with the UPT graduate and report a high degree of satisfaction with the quality of their entering students. Seventy percent of the staff and instructor force of the five aircraft, stated that the UPT graduate entering their schools had either excellent or good preparation. Thirty percent stated fair preparation and not one instructor or staff selected poor preparation.

Two, how extensive would the anticipated training benefits actually be? If the initial better performance of the SUPT-trained student is overcome by experience prior to his/her completion of CCTS, (as stated by C-130 instructor pilots) SUPT would offer little advantage over the present UPT. On the other hand, if the better performance carries over to the operational assignment and beyond, a real long-term savings may be demonstrated.

Three, how difficult is it for the present CCTS programs to overcome initial student weaknesses? Although several weak areas were mentioned by both CCTS students and instructors, there was no indication that they were particularly difficult to overcome once the student entered the CCTS program. To illustrate this point, the advice to study harder while in UPT appeared more frequently on the questionnaires than the advice to change UPT. There was also some indication that certain areas of flying are intrinsically difficult (e.g., air refueling) no matter what sort of prior training the student has, while others (e.g., normal takeoff use) are not so hard. The point is that practical benefits of SUPT cannot be easily demonstrated for problems that can easily be overcome in a CCTS. At the same time, changes to UPT can be justified if they benefit areas which are intrinsically difficult.

Finally, how much operational training should be covered in UPT? The historical reason for teaching everything possible in UPT was that it is much much cheaper to fly a trainer aircraft than a B-52 or C-141. The CCTSs were committed to train in the air because of the lack of realistic ground training. Now, however, SAC and MAC have made rapid advancement in their WST/Sim acquisitions of the latest, state-of-the-art equipment. They project a substantial decrease in flying training hours. Therefore, the most effective course might be to teach only basic flying in UPT; and mission train in the CCTS on the equipment that will actually be used, relying more heavily on simulators to compensate for the cost of operational training in CCTSs. However, the optimum course certainly cannot be specified until the benefits formula is applied more extensively and studies of benefits mixes are conducted.

APPENDIX C

GENERALIZABILITY METHOD FOR TTB TRAINING TASKS

## CHAPTER 1

### INTRODUCTION TO THE METHOD

This section describes a method of estimating the extent that training tasks in SUPT will generalize to the operational tasks of the TTB pilot. The method includes analytic and comparative steps, and involves concepts from both task analysis and perceptual learning.

#### 1.1 ANALYSIS AND COMPARISON

In the analytic steps of the method, tasks to be assessed for generalizability are subjected to a task analysis type of breakdown. As with a traditional task analysis, the training tasks are analyzed into successively finer levels of detail. However, instead of ultimately breaking out specific behaviors, conditions and standards of the tasks and subtasks, the generalizability method analyzes the tasks in terms of stimulus response components. That is, the method isolates and examines the stimuli and patterns to which the pilot attends as he/she performs the task, as well as the specific details and patterns of his/her responses.

In the comparative steps of the method, the training task is compared from one vehicle to the next, the levels of similarity are identified, and numerical values are assigned. These numerical values are assigned in two ways: (1) on the basis of the presence or absence of a common dimension of the task, (2) on the basis of degree or amount of overlap on the common dimension. A simple calculation of generalizability can be based upon the former

assignment of values (i.e., upon presence or absence of common dimensions). A more refined calculation can be computed when both sets of values are taken together.

The calculations made in the comparative steps provide an index of generalizability, called G, which can be roughly equated with probability in the following way: (1) at the higher, less detailed levels of analysis, the probability that a stimulus-response set will be repeated from one training medium to the next is easy to verify. In other words (to take an extremely simplistic example) the probability that all TTB pilots will initiate lift-off by (a) observing some subset of stimuli (IAS, runway markers, etc.) and (b) making a generic response (back pressure on the yoke) is both verifiable and quantifiable (i.e.,  $p = 1.0$ ). (2) At the lower more detailed levels of analysis, the specific details, or elements of the tasks can be compared in the same way. The greater the number of common task elements or dimensions which are found upon comparison, the more likely the behavior is to be repeated from one aircraft type to the next. The fewer common dimensions which are found, the less likely the behavior is to be repeated. To give another simple example, maintaining directional control on takeoff roll is a must for all TTB aircraft. However, for some portion of takeoff, some pilots will use nosewheel steering and/or rudder control, and others will differentially brake. Thus, at the higher task level, (maintaining a position relative to the centerline), the behavior is repeated; yet at the lower dimension level, only portions of the response will be common, or repeated, for all aircraft. The probability will be less than 1.0.

The generalizability method is non-specific in the sense that it is not tied to any particular type or class of vehicle or learning medium. Though developed in the context of generalizability of UPT training to TTB aircraft, it can be used to estimate the generalizability of training between any two types of aircraft or between simulator and aircraft, etc. Moreover, it is not specific to the flight training environment. The method will estimate the generalizability of any type of training task which is subject to analysis and can be compared from one learning medium to another. Thus, it is a general purpose method.

## 1.2 PERCEPTUAL LEARNING

The generalizability method is based in part on the fact that crew members utilize perceptual learning as they acquire perceptual and motor skills.

As indicated in Figure C-1, perceptual learning encompasses both environmental and procedural factors. Environmental factors include visual scenes, or pictures, sounds, and feel associated with flying an aircraft. Procedural factors include the sequential steps of a particular task as well as chained events which occur during a mission.

The environmental cues can be broken down into three categories: (1) those coming from the instruments, (2) those due to the aerodynamics and feel of the aircraft, and (3) environmental visual cues.

1. The stimuli coming from the instruments can take the forms of isolated readings and patterns of readings. An airspeed indicator gives an isolated reading. A check of engine oil pressures on a multi-engine aircraft is a partial check to see if the pattern of the multiple gauges is consistent.
2. The basic aerodynamic and structural design of an aircraft gives cues to the pilot as to the aircraft's reaction to configuration changes, e.g., flap and gear extensions, and air brakes and power adjustments. The aircraft simply feels a certain way at certain phases of certain flight modes.
3. The pilot may also receive cues as to basic variables such as altitude and airspeed from the pilot's perceived vision of the outside world as constrained by the design of the cockpit and windscreens. Such cues are particularly important at takeoff and landing.

The important fact concerning procedural cues is that some training is specific to a mission. The procedures involved are not necessarily tied to a specific aircraft. (Examples are holding pattern procedures.) In these cases, the cues come from the steps and the procedures of the mission. Each step taken by the pilot, or by another crewman and communicated to the pilot, may serve as a cue for the next behavior to be executed.

It is important to the estimation of generalizability that these factors can be specified with some analytic effort, stated objectively, and eventually

quantified. This allows training tasks to be broken down into tractable elements, each of which can be compared and contrasted across media in a search for underlying similarities or commonalities. Once these commonalities are identified, a large body of knowledge from the psychology of learning can be utilized in estimating generalizability.

1. Identical or very similar cues (both physical and procedural) can be counted in the training and operational situations. The greater the overlap, the higher the probability that the behavior will be recalled and used in some manner. Generalization gradients, based on physical or other dimensions, are relevant here. For example, the angle of attack in the trainer in final approach to landing should probably be psychologically similar to that of the operational aircraft.
2. Identical or very similar responses to these cues can also be counted in the training and operational situations. Again, the greater the overlap, the higher the generalizability of the task. The related concept of discrimination, or splintering of basic learning into finer areas, can also be used. For example, learning the general concepts of a takeoff, and then refining the concepts to other aircraft, is preferable to learning only the precise parameters of takeoff in the plane which happens to be the trainer.

Examples of the generalizability method presented later are focused more directly upon the first two examples; that is, upon similarities among cues

(stimuli) and responses to these cues. The method can be implemented upon cues and responses with analysis and quantification of the elements of the training task. However, the method can equally incorporate the principles of generalization and discrimination as long as their respective gradients can be specified. These gradients would be used to specify the amount or degree of overlap among task elements with great precision and accuracy. Such an approach would require more effort in the way of analysis and, perhaps, quantification yet would improve the accuracy of the estimates of generalizability.

Essentially, generalizable tasks include those in which the student can "see a pattern" in either environmental or procedural cues, and in which he/she can later refine that pattern rather than re-structure it.

As an example of such a pattern, consider the procedures immediately after takeoff. In all jet aircraft, it is necessary to (1) raise the landing gear, (2) raise the flaps, and (3) adjust power. The handles and indicators may be located in different places in different cockpits but the basic three-step pattern remains the same.

There seems to have been no thorough review of the ability to "see the pattern" as related to flight training. However, a recent experiment (Crosby, 1977) shows high transfer of training resulting from "cognitive pretraining" in which students presumably learned "schema" which helped them to recognize patterns.

Furthermore, studies of training in other fields indicate that pattern recognition can be vitally important. For example, a graphics computer terminal can show a person under with information; and a videotape study of experienced and inexperienced programmers has shown that the experienced programmers have learned where to look: They know what to ignore, what to pay attention to, and what patterns to recognize (Overton, 1973).

Comparable perceptual learning probably begins early in flight training. Perhaps the pilot learns to ignore rattles (e.g., from a flashlight in a map case) and pay attention to buffeting. Perhaps he/she learns to ignore minor changes in cabin illumination and pay attention to the instruments. Perhaps she/he learns that the width of the centerline on the runway is irrelevant, but that the line's location and orientation are vital cues to directional control on take off.

In summary, those tasks which are relatively generalizable tend to include tasks in which the student learns to recognize patterns in complex stimulus arrays, in which he/she learns to distinguish between relevant and irrelevant stimuli, and in which he/she "sees" patterns in his/her own responses. Identification of such tasks may be partly subjective; but the generalizability method described in Chapter 2 permits a relatively objective identification of some such tasks.

## CHAPTER 2

### THE METHOD

#### 2.1 OVERVIEW

The generalizability method can provide increasing precision with the application of greater analytic and quantification effort.

In order to apply the method in a thorough manner, a formalized set of steps is used. An illustration of these steps is shown in figure C-1 in the form of a quasi-computer flow chart.

Logicon has not actually gone through all the steps in figure C-1 although the company has used a similar method to analyze several sample training tasks. The results were very promising, and in the sense that they seemed realistic, useful estimates of generalizability may be expected.

#### 2.2 STEPS OF THE METHOD

Step 1: Select Task 1. Accomplished in one of two ways (1) a task can be selected on its own merit (i.e., without reference to a specific aircraft) as a likely candidate for generalizability, and (2) a task which is specific to a particular aircraft can be selected and compared to the same task on another aircraft.

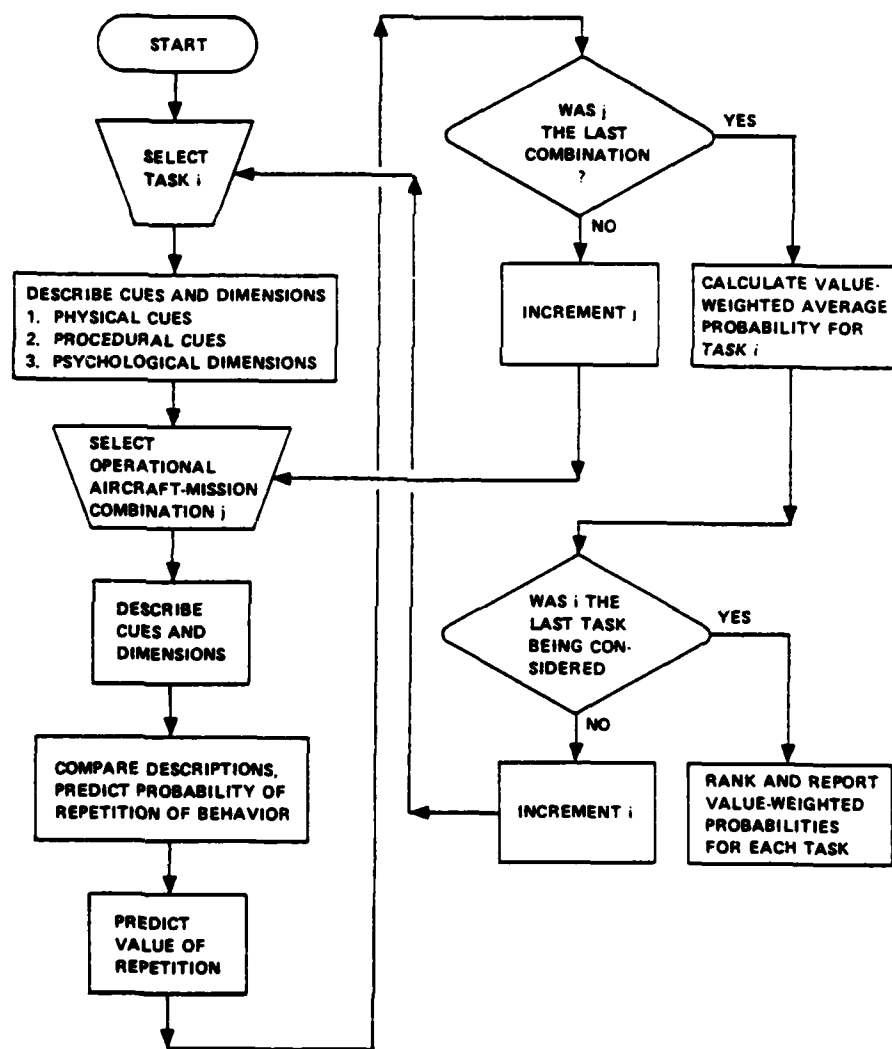


Figure C-1. Steps in the Method

Step 2: Describe Cues and Dimensions. The analytic step of the method. This is discussed in detail in the following section.

Step 3: Select Operational Aircraft-Mission Combination j. Identifies the task as it relates to a specific aircraft and mission. The aircraft/mission combination provides real-world cues and response dimensions for the task and constitutes the basis for comparing tasks across aircraft.

Step 4: Describe Cues and Dimensions. Must be repeated for the aircraft/mission-specific task.

Step 5: Compare Descriptions, Predict Probability of Repetition of Behavior. The comparative step of the method. Here the index of generalizability (G) is calculated. This step is discussed in detail in the following section.

Step 6: Predict Value of Repetition. Provides training personnel an opportunity to weight the index G in terms of training costs etc., associated with the task under consideration. For example, if a task is extremely difficult or costly to train, the value of its ability to generalize across aircraft would be greater than for a less costly task.

Step 7: Was j the last combination? Used for completeness; that is, have all the aircraft/mission combinations which are relevant to a particular task been considered?

Step 8: Calculate Value-weighted Average Probability for Task i. Provides an average generalizability value for the task across all aircraft/mission combinations which have been considered.

Step 9: Was i the last task being considered? Used for completeness; that is, have all relevant tasks been considered?

Step 10: Rank and Report Value-weighted Probabilities for Each Task. Provides a ranked listing of weighted indices of generalizability for all the training tasks considered by the method.

### 2.3 ANALYTICAL AND COMPARATIVE DETAILS

Referring to figure C-1 two blocks in the flow chart requiring clarification are entitled "Describe Cues and Dimensions" and "Compare Descriptions, Predict Probability of Behavior." These blocks (2 and 5) represent the analytic and comparative steps respectively of the complete method and are clarified in the following pages. The first step, "Describe Cues and Dimensions," describes the levels of analysis which must be accomplished to compare training tasks across media. The second step, "Compare Descriptions, etc.," describes the comparison itself, which involves the calculation of an index of generalizability. It also provides an example of such a calculation.

### 2.3.1 Descriptive Steps

It is necessary to describe the physical cues, procedural cues, and psychological dimensions.

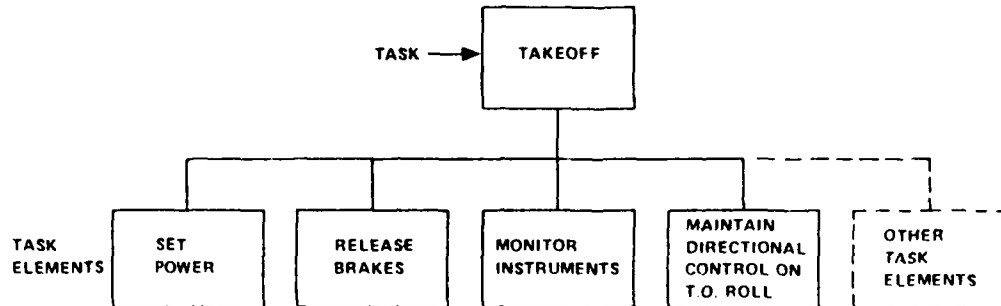
Description of the cues and dimensions of the selected task requires the following levels of analysis, and a final, non-analytic step, which must be performed in sequence:

Note: This analysis assumes that each of the tasks/elements treated by the generalizability method may be represented on the projected TTB training aircraft (TTBT) eventually used in UPT.

<u>Level 1.</u>	This level of analysis separates the task into units or ele-
Analyze	ments which are amenable to individual treatment and addition-
Task	al analysis.

1.0. Analyze the task into its generic elements; that is, elements which are (1) specific to the task and (2) can be described as separate entities.

EX: For the task of takeoff, some of the generic elements are set power, release brakes, monitor instruments, maintain directional control on takeoff roll, etc.

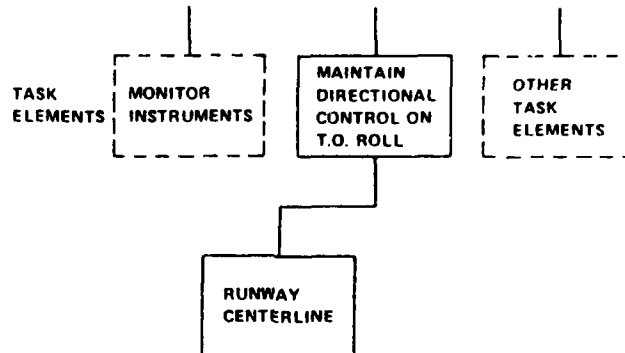


Level 2. In this level, the cues to which the pilot attends and the responses he/she makes to these cues are identified for each generic task element. Cues (a) and responses (b) are then described in qualitative terms.

#### Level 2a: Cues

2.a.1. For each element, identify the physical and procedural cues to which the pilot attends.

EX: For the task element of maintain directional control on takeoff roll, a cue is runway centerline.



Note: While this description of the method does not treat physical and procedural cues separately, the distinction is implied. In addition, this discussion does not intend to imply that runway centerline is the only cue used by the pilot to maintain directional control. Runway centerline is chosen because (1) it is an important cue and (2) for demonstration purposes.

2.a.2. Describe each cue identified in 2.a.1. in qualitative terms by identifying its salient features/dimensions. Use the following definition:

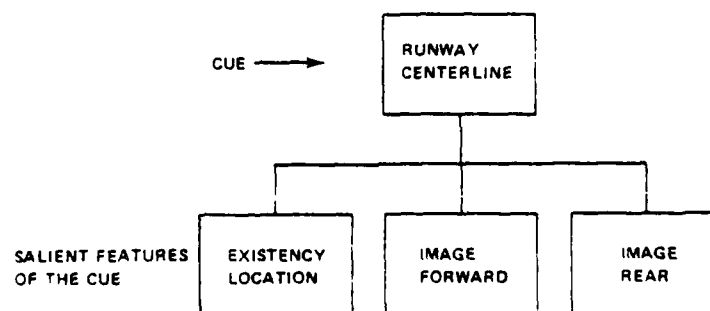
\* A salient feature/dimension is a specific feature or dimension of the cue to which the pilot responds in accomplishing the task element or portion thereof.

Ex: Given the cue centerline, the pilot must first perceive it. Next, he/she perceives it in some relationship to the pilot or aircraft (e.g., location). He/she also may use it as a basis for extrapolation of an imaginary centerline to visual infinity on the horizon and/or to some reference point in the cockpit as a means of maintaining a constant ground track. The description of the cue, centerline, in terms of salient features, can be summarized as follows:

<u>Cue</u>	<u>Feature</u>
centerline	<ul style="list-style-type: none"> <li>existence/location</li> <li>extrapolation of imaginary centerline extended forward to visual infinity</li> <li>extrapolation of imaginary extended centerline rearward to cockpit reference point</li> </ul>

For future reference these cues can be more conveniently summarized.

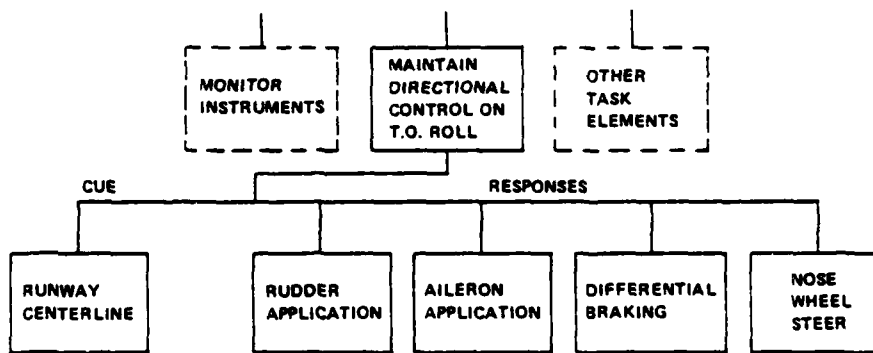
centerline	<ul style="list-style-type: none"> <li>centerline, existence/location</li> <li>centerline image forward</li> <li>centerline image rear</li> </ul>
------------	---



## Level 2b: Responses

2.b.1. For each task element, identify the responses the pilot makes to each cue identified in 2.a.1.

EX: Responses to the cue, centerline, would be rudder application, aileron application, differential braking, nose wheel steering.



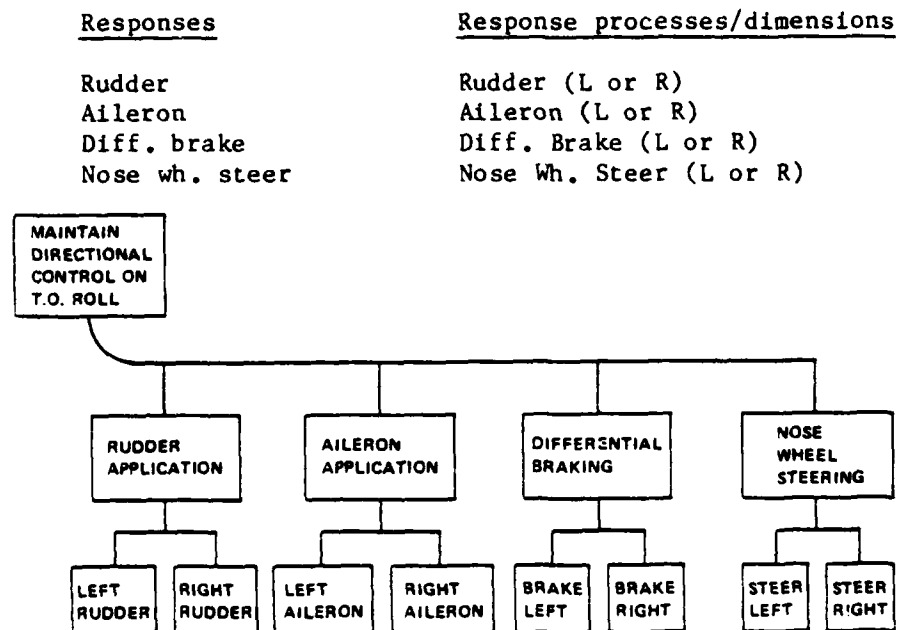
2.b.2. Describe each response identified in 2.b.1. in qualitative terms; that is, identify its underlying processes/dimensions. Use the following guideline.

Specific processes/dimensions of the response can be associated with the cues identified in 2.a.1. They must be identified and described in enough detail that their general nature can be determined.

EX: At a general level, the typical response to the cue, centerline, is to use that cue to maintain directional

control on takeoff roll. This response reduces to the application of rudder/aileron etc. in a particular way (e.g., left or right rudder) upon perceiving some particular feature of the cue (e.g., location of the centerline with respect to the aircraft).

The description of response processes/dimensions can be summarized as:



Specifically, if the centerline (real or imaginary, extended) appears to the left of where the pilot thinks it should be, he/she will move the aircraft to the left by means of one or more of the response options available to him/her. That is, he/she will move the aircraft left by means of rudder, aileron, differential braking or nose wheel steering. The following chart (figure C-2) shows both cues (stimuli) and responses for both sublevels of level 2. The chart starts with the task element, maintain directional control, etc., and ends with the specific left stimulus/response situation just described.

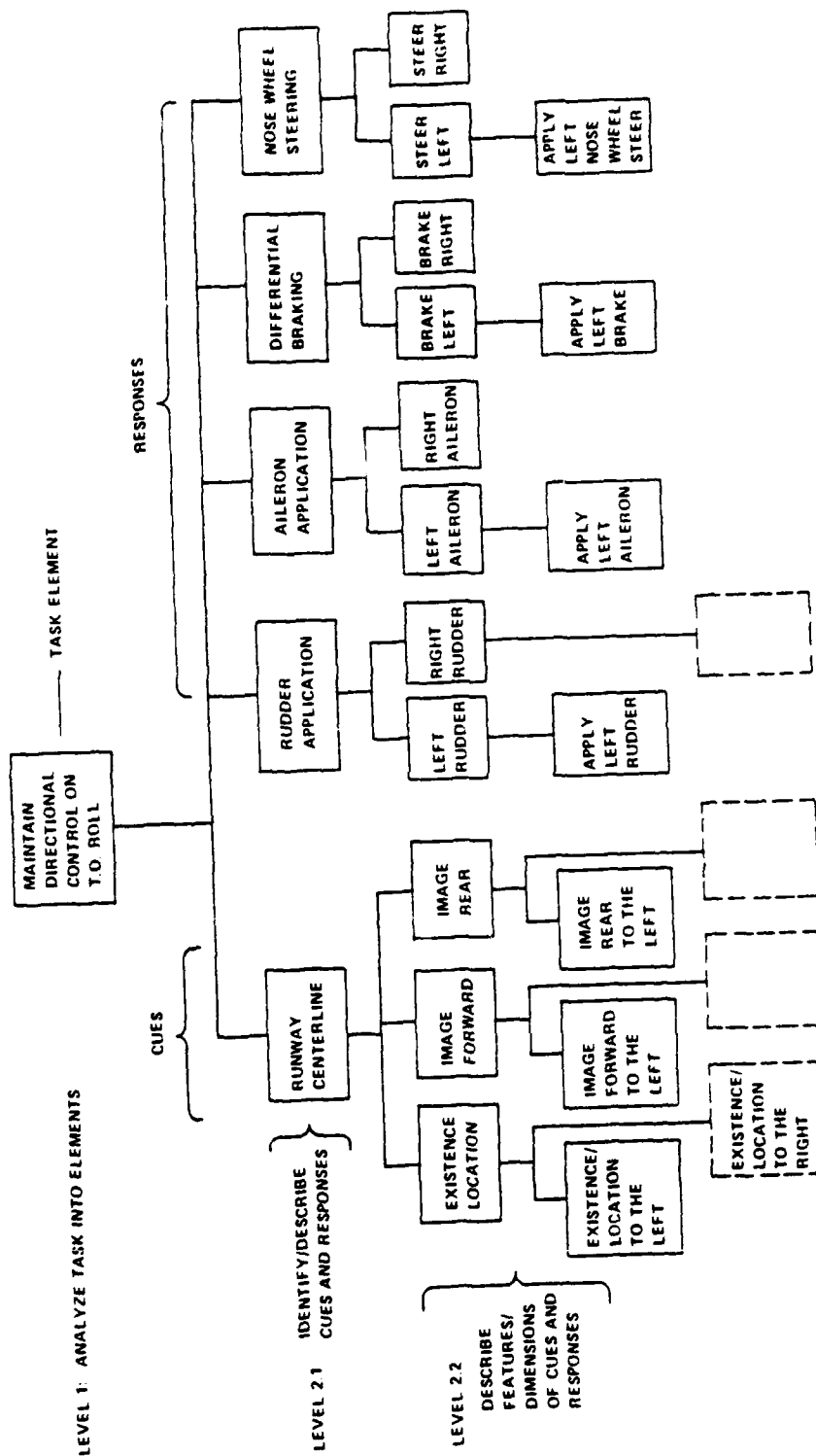


Figure C-2. Levels of Analysis

Level 3. In this level, the features/processes/dimensions of cues and Quantitative responses are described in quantifiable terms; that is, each Description dimension is specified in terms of measurable parameters. For of Task this process, use the following guidelines:

1. Note that some of the level 2 qualitative descriptions are amenable to quantification as described in that level.
2. For cognitive tasks, the analysis/description of the feature should continue until the actual decisions are reached, calculations are made (or implied), matching processes are used, etc.
3. For the psychomotor tasks, the analysis/description should continue until the level of the actual physical dimensions of the task are reached; e.g., movement of the yoke, movement of the rudder pedals, etc.
4. For the perceptual tasks, the analysis/description should continue until the perceptual dimensions/processes are reached; e.g., the dimension along which the imaginary centerline is extended, sensation of diminishing yoke/rudder pressure as the aircraft is being trimmed, objects being looked at or patterns being recognized are identified.

5. For the affective tasks, the analysis/description should continue until processes or dimensions, such as complacency, which impacts mission effectiveness and safety, are uncovered.
6. For the task elements representing a combination of behavioral components (e.g., perceptual-cognitive), continue the analysis until one process emerges as dominant or until the combination is sufficiently refined to work with.
7. For any type of task, explore the possibility of quantification in terms of derived measures; that is, ratios, difference measures, and other mathematical relationships.

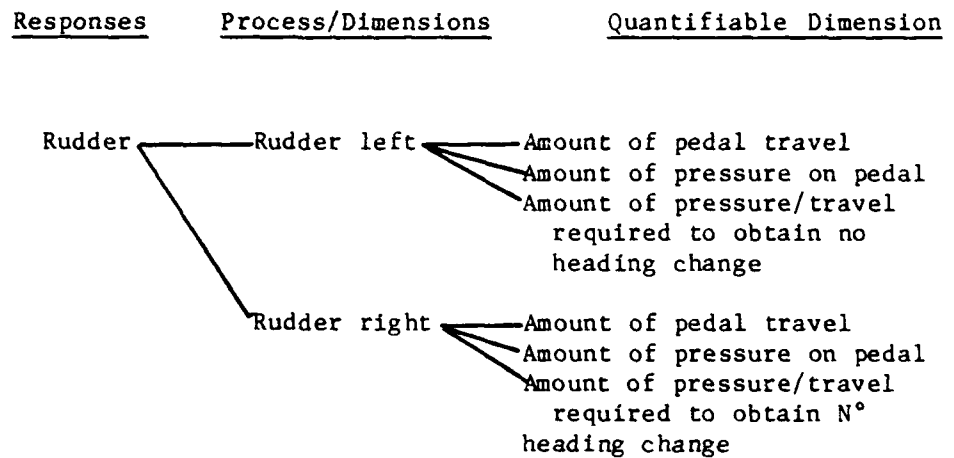
Level 3a: Cues

<u>Cue</u>	<u>Features/Dimensions</u>	<u>Quantifiable Dimension</u>
Centerline	Existence/location	Distance from pilot reference pt.
		Visual angle from reference pt.
	Image forward	Distance from reference pt.
		Visual angle from reference pt.
	Image rear	Distance from reference pt.
		Visual angle from reference pt.

# Level 3b: Responses

3.b. Using the guidelines of 3.a., describe each process/  
dimension of each response in quantifiable terms.

EX:



Obviously, there are a variety of ways to quantify the features/dimensions of the cue and responses which were chosen for this discussion. Two ways of quantifying features of the cue, and three ways of quantifying response dimensions are shown in figure C-3. These may be matched in any reasonable combination; that is, either distance or visual angle of the centerline from the pilot's reference point may be matched with some measurable amount of rudder pedal travel. Either may also be matched with pressure on the rudder pedal. Figure C-3 (a continuation of figure C-2) shows one matching possibility which might be used for the estimation of generalizability. The correct matching of stimulus feature to response dimension may be determined on

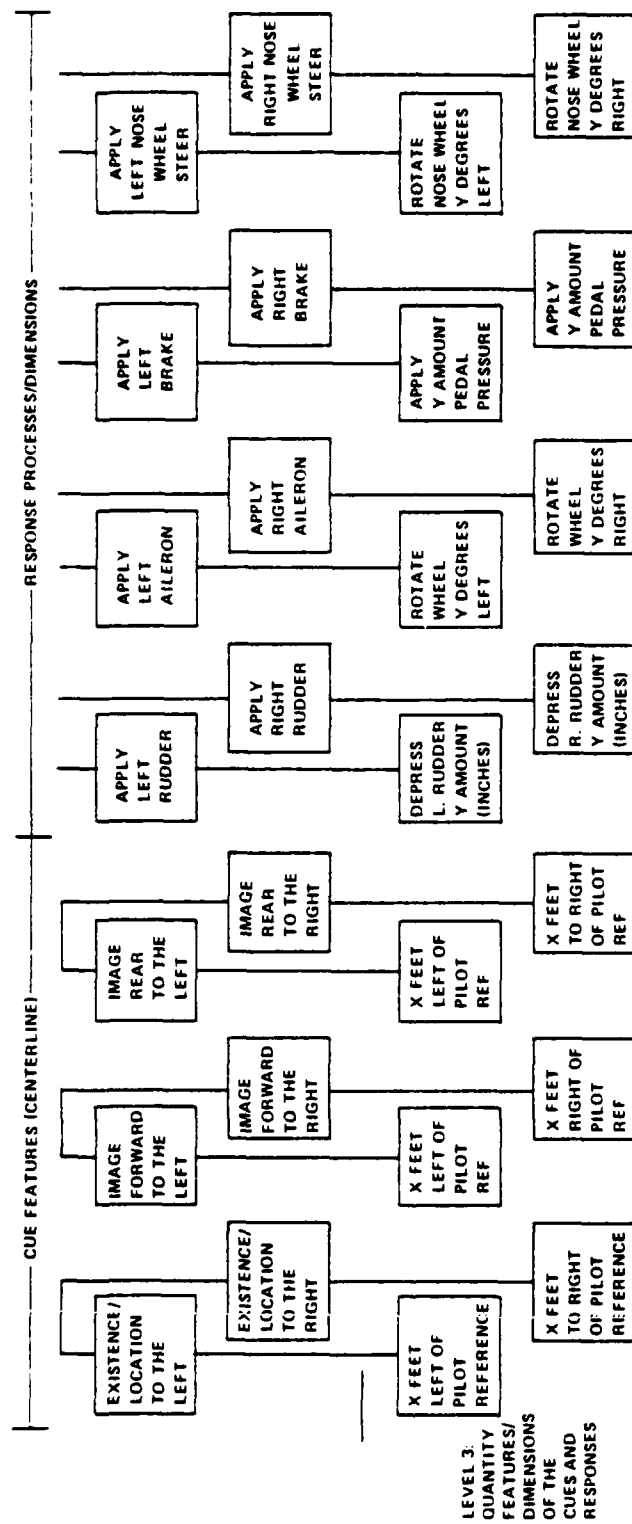


Figure C-3. Qualification of Cues and Responses

an empirical basis; that is, which matching combination provides the best predictions?

### 2.3.2 Comparisons and Predictions

Comparisons of task descriptions can be made either within levels or between levels. Within levels refers to a comparison made exclusively at one of the levels of analysis described in the previous step, Describe Cues and Dimensions. This comparison involves a simple counting, across media, of the common dimensions, etc., found at the given level, and the calculation of the ratio of these common dimensions to the total number of dimensions available at that level. The formula for this comparison, which assumes that task generalizability is a simple function of commonalities among task elements, dimensions, etc., is:

$$G \text{ (within)} = \frac{D_{C(T1,T2)}}{D_s}; \text{ where}$$

G is Generalizability

$D_{C(T1,T2)}$  is the number of dimensions in common when

the task is exercised in different media; i.e.,

T1 refers to the task as exercised in medium 1

T2 refers to the same task in medium 2.

$D_s$  is the sum of all dimensions treated in any one comparison.

Between levels refers to a within-level comparison which is refined or weighted by the inclusion of data from the next lower level of analysis.

This comparison looks not only at common task dimensions across media, but also looks at the next level to the amount or degree of overlap along the dimensions which are common. The formula for this comparison, which assumes that task generalizability is a joint function of commonalities among dimensions and of overlap along the common dimensions, is:

$$G \text{ (Between)} = \frac{D_{C(T1,T2)}}{D_s} \frac{O_D^1}{D_{C(T1,T2)}} ; \text{ where}$$

previously defined terms/factors are the same, and  $O_D^1$  refers to the amount/degree of overlap along the common dimensions. This formula may be stated in words as:

$$G \text{ (between)} = (\% \text{ of common tasks}) (\% \text{ overlap among them})$$

Task descriptions can be compared by means of either of the two formulae at any level of analysis. For example, at level 1, if the within-level comparison is made, a large number of common task elements would imply that the task is highly generalizable across the media compared. If the between-level comparison is made,  $G$ , calculated for level 1 would be refined or weighted in terms of the number of level 2.1 cues and responses they have in common. In turn, starting at level 2.1, comparison can either be made within the level, or weighted in terms of common features/processes/dimensions of level 2.2. Finally, comparisons among dimensions can be refined in terms of their actual quantitative values at level 3.0

Any of these comparisons can be made separately for either cues or responses. For example, the specification of a TTB-track trainer for UPT might require a look at the stimulus/cue environment in isolation. In such a case, one could make any or all the within/between comparisons for physical or procedural cues, without having to treat the responses. Such separate comparisons are possible because, for any calculation, each dimension, or portion thereof, is reduced to a simple numerical value.

The comparison of task descriptions, and subsequent calculation of  $G$ , requires the following steps to be carried out in sequence:

Step 1. For each task, determine level of analysis upon which to base the generalizability calculation.

Note: This determination is a training decision and is based on factors which are external to the method itself. As noted above, each succeeding level of detail provides a more refined generalizability calculation; therefore, it is advisable to base the calculation upon the most refined analytic data which are available.

Step 2. For each task determine the type of calculation desired; that is  $G$  (within) or  $G$  (between). Use the following guidelines:

2a. If only one level of analytic data is available, then only  $G$  (within) can be calculated.

2b. If at least two levels of analytic data are available, then always calculate G (between), unless:

1. The task is known to be generalizable on the basis of previous comparisons and a more refined estimate is needed.
2. The value of the training decision does not warrant the more complex calculation.

Step 3. Assign numerical values to the features/processes/dimensions of the training tasks. Use the following rules:

- 3a. For a within-level calculation, assign binary values of 1 and 0 to the dimensions, etc. If the dimension is common across media, assign the value, 1. If an identified dimension is not common across media, assign the value, 0.
- 3b. For a between-level calculation, assign binary values, as discussed above, to the upper-level dimensions, and calculate overlap along the dimensions at the more detailed level (see following example for a calculation of overlap.)

Step 4. Using the appropriate formula, calculate G.

Example 1, calculation of G (within): From the training task, takeoff, the element, maintain directional control on takeoff roll, is selected for this example.

(Step 1) Determine level of analysis

As noted above, the level of analysis selected is a training decision. For present purposes, assume data from level 2.1 are available and sufficient.

(Step 2) Determine type of calculation

For this example, assume G (within) is sufficient.

(Step 3) Assign values

For a within-level calculation, only binary values of 0 and 1 are assigned to the cue/response dimensions, processes, etc. Data for this example follow from the previous section, Describe Cues and Dimensions.

Medium 1 (e.g., TTBT)

Medium 2 (e.g., C-135)

<u>Cues</u>	<u>Value</u>	<u>Responses</u>	<u>Value</u>	<u>Cues</u>	<u>Value</u>	<u>Responses</u>	<u>Value</u>
Center-	1	Rudder	1	Center-	1	Rudder	1
line		Aileron	0	line		Aileron	1
		Diff. Brake	0			*NWS	0

\*Nose wheel steering

Note: For this example, it has been assumed that the projected TTBT trainer uses differential braking on takeoff roll, but does not have nose wheel steering. It is also assumed, only for exemplary purposes, that C-135 pilots do not use differential braking since they have nose wheel steering. Thus NWS and differential braking responses have each received a value of 0 in the matrix.

(Step 4) Calculate G

The formula for G (within) is  $\frac{D_{C(T1,T2)}}{D_s}$ .

In the numerator,  $D_{C(T1,T2)}$  = centerline (1), rudder

(1), aileron (1), diff. brake (0), NWS (0) = 1+1+1+0+0=3.

In the denominator,  $D_s$  = centerline \*(1), rudder (1),

aileron (1), diff. brake (1), NWS (1) = 1+1+1+1+1=5.

\*Denominator entries (dimensions) all receive a value of 1, whether or not they are common to both media, since a ratio of common dimensions must be calculated.  
total dimensions

$$G(\text{within}) (\text{TTBT vs. C-135}) = \frac{1+1+1+0+0}{1+1+1+1+1} = 3/5 = 0.6$$

Example 2, calculation of G (between):

(Step 1) Same as example 1, above.

(Step 2) Assume data from levels 2.1 and 2.2 are available.

(Step 3) For this example G (between) is calculated.

(Step 4) For a between-level calculation, binary values of 0 and 1 are assigned to the higher level (2.1) cues/responses and amount of overlap must be calculated for the lower level (2.2) dimensions, processes, etc.

(4a.) For this example level 2.1 data and calculations from the previous example are used. Thus, value of the first factor,

$$\frac{D_C(T1, T2)}{D_S} = 0.6, \text{ is given.}$$

(4b.) What remains is to calculate the overlap on the common dimensions, etc., from level 2.2 for the 2nd factor below:

$$\frac{\sum_{i=1}^D o_D^i}{D_{C(T1,T2)}}$$

The common dimensions are centerline, rudder, and aileron. Treating the cue first, it can be seen from the analytic steps of this method that the cue, centerline, can be broken into 3 features, namely:

(From level 2.a.2)

<u>Cue</u>	<u>Features</u>
centerline	centerline, real/location
	centerline image forward
	centerline image rear

At this level of analysis, responses are:

(From level 2.b.2)

<u>Responses</u>	<u>Process/Dimension</u>
Rudder	Left
	Right
Aileron	Left
	Right

To calculate overlap on these data, it is assumed for demonstration purposes that:

1. TTBT instructors train their students to attend to centerline, real, and image forward, and C-135 instructors train on all three features of the cue.
2. Both aircraft require qualitatively similar L/R responses on rudder and aileron.

Based on the first assumption, overlap on features of the cue is 2/3; that is, 2 of the 3 features are common.

Based on the second assumption, overlap on both common response dimensions is 1.0; that is, for both rudder and aileron, the responses are qualitatively identical. Thus,

$$\frac{\sum o_D}{D_{C(T1,T2)}} = \frac{2/_{3+1+1}}{1+1+1} = 0.89$$

Recalling that the complete equation of a between-levels calculation is

$$G = \frac{D_{C(T1,T2)}}{D_S} \frac{\sum o_D}{D_{C(T1,T2)}}$$

the refined value is obtained by multiplication.

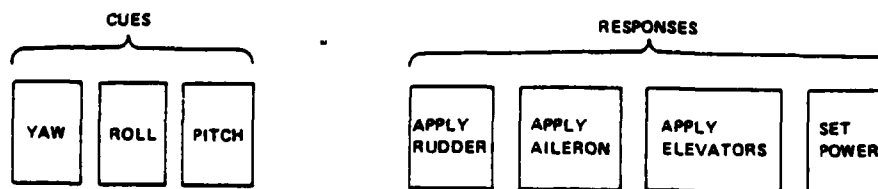
$$\text{Thus } G = 0.6 \times 0.89 = .534$$

By way of an intuitive explanation, the original value, calculated totally within a particular level of analysis, is refined by a weighting scheme which considers a finer grain of data. The initial calculation yielded an index of 0.6. The refined calculation yielded 0.534, which is probably a more accurate reflection of expected generalizability of the task than the larger number.

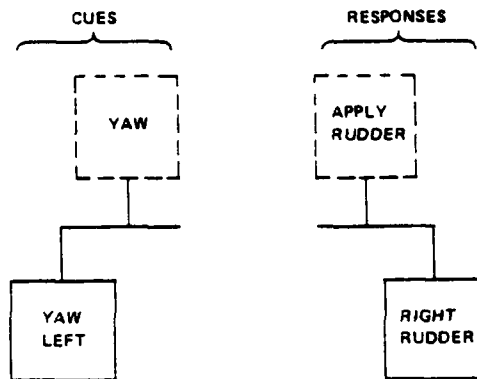
CHAPTER 3  
ADDITIONAL EXAMPLES

3.1 ASYMMETRICAL THRUST PROCEDURES

By way of introduction, this example was exercised through the media of the C-135 and C-141, which are similar in weight and number of engines which are mounted on the wings. Given loss of an outboard engine, during cruise, the immediate problem in either aircraft is basic control under conditions of asymmetric thrust. Following the format of the previous examples, the task element is Asymmetric Thrust Procedures. Analyzing the task from this point, the immediate cues and responses are:



Each of the more general-level cues and responses will be essentially the same for both aircraft. Thus the within-level calculation would yield 1.0. At the next level of analysis, cues and responses would still be common to all multi-engine aircraft; for example,

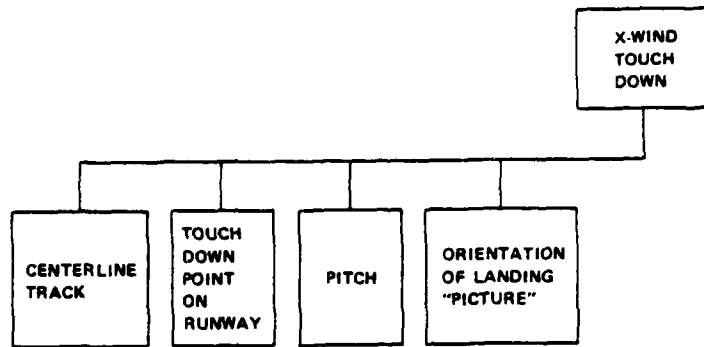


The same general pattern holds for roll and pitch. Therefore, the more refined calculation of G (between-levels) would also yield 1.0 (i.e., at the level of qualitative description of cues and responses). The task of countering asymmetric thrust flight is much the same for the two multi-engine aircraft. With additional analysis and quantification of the features/dimensions of cues and responses, detail differences between the aircraft would begin to emerge. These differences would tend to reduce succeeding calculation of G to a lower figure by virtue of such factors as difference in rudder pedal pressures, etc.

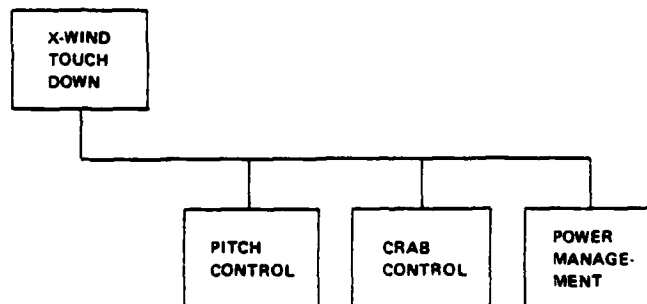
### 3.2 LANDINGS

This example covers the landing approach and touchdown under crosswind conditions. The analysis was carried out with subject-matter experts and the B-52 was compared with the C-135. The exercise started with flare, or round-out and ended with wheels on the runway.

The cues, or attended stimuli, were



Response procedures/dimensions were:



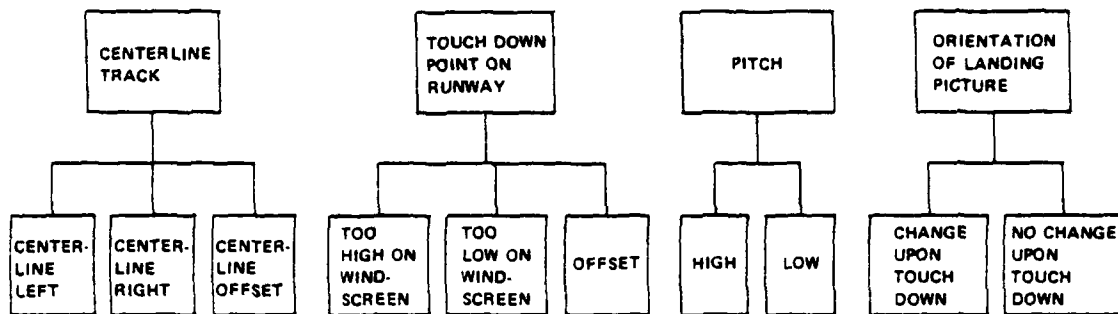
For a within-level (simplified) calculation (looking at the cues), center-line track touchdown point and pitch are common. Orientation of a landing picture is not common. Looking at the responses, power management and pitch control are common. Crab control is not common. Assigning a binary value of 1 to the common and 0 to the uncommon, cues and responses resulted in the following:

Cues Responses

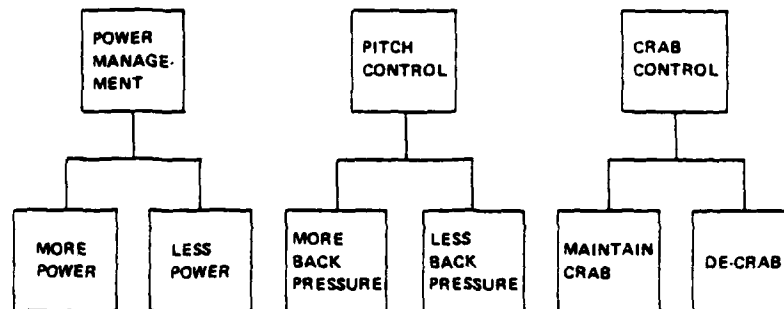
$$\frac{\overbrace{1+1+1+0} + \overbrace{1+1+0}}{1+1+1+1+1+1} = 4/7 = 0.571$$

At the more refined level of analysis (between-levels), the following results are obtained:

For the cues, the salient features are found in the following diagram.



and for the responses, the underlying processes/demensions are:



Recalling that the refined calculation is one of overlap along the common dimensions, the features of centerline left and right, for centerline track, are overlapping features for both B-52 and C-135. Centerline offset is a salient feature for the C-135 only. Thus, the value obtained is:

$$\frac{1+1+0}{1+1+1} = 2/3$$

Similarly, for touchdown point on runway, offset is salient feature for the C-135 only; thus the value obtained is:

$$\frac{1+1+0}{1+1+1} = 2/3$$

For pitch, both features are common to both aircraft, yielding a value of 1.0.

Orientation of landing picture is not a common cue, therefore no calculations are made.

Turning to response dimensions, no critical differences were found between aircraft for either power management or pitch control; therefore, the dimensions are assumed to overlap completely. Obtained values were 1.0 and 1.0 respectively. No calculations were made for crab control, since it was deemed not common at the higher level of analysis. The total set of refining values for the calculation is

$2/3 + 2/3 + 1 + 1 + 1$ . When divided by the appropriate denominator (total number of possibly overlapping dimensions), the refining factor becomes

$$\frac{2/3 + 2/3 + 1 + 1 + 1}{5} = \frac{4.334}{5} = 0.87$$

Multiplication of the two factors results in generalizability (G) of  $.571 \times .867 = 0.49$ .

## CHAPTER 4

### DISCUSSION

Given the proposed, general-purpose method, a number of important decisions have to be made in its implementation. Perhaps the most important is the level of analysis required for the calculation of G. Logicon's recommendation is that for most training tasks, a careful qualitative analysis is required for preliminary screening. This level of analysis is represented as level 2 in the preceding discussion. It is also recommended that the refined, between-level calculation be made, which means that both sub-levels of level 2 be used. (Recall that the initial calculation is made at level 2.1 and refined or weighted in terms of the more detailed information in level 2.2.)

Some tasks may be near the threshold for inclusion in, or exclusion from a training program, and others may be controversial. For these tasks, it is recommended that the features/dimensions of the task be quantified and used to refine the generalizability estimate accordingly.

One should consider, however, the fact that the quantification of the underlying dimensions of flying tasks, with a high degree of accuracy, could become very time-consuming. Quantification would have to consider thrust differences of the engine, differences in amount of power assist for flight controls, differences in pedal travel, etc., among all the aircraft compared.

The most viable supplement to this mass of detailed data involves pattern recognition. Psychologists and subject-matter experts could examine the subtasks to see which contained the most distinct patterns and involved the most perceptual learning. Both stimulus and response patterns should be sought. Since perceptual learning is believed to be highly generalizable, these tasks should be relatively generalizable. Although this procedure is somewhat subjective, it may be a valid supplement to the calculations above if a consensus is reached regarding which tasks involve the most perceptual learning and, therefore, should be most generalizable.

Finally, generalizability should be considered as only one determinant of the training tasks benefits, and all factors should be subject to inspection. A method for accomplishing this is discussed in "Full Formula Results," in Section 1, Chapter 3.

#### REFERENCES

- Crosby, J.V. Cognitive Pretraining (AFHRL-TR-77-62). USAF, Williams AFB, AZ: 1977.
- Overton, R.K. Research Toward Ways of Improving Software Maintenance. (ESD-TR-73-125). USAF, Hanscom Field, MA: 1973.

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FOR THE COMMANDER

*Wendell L Anderson*

WENDELL L. ANDERSON, Lt Col, USAF  
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